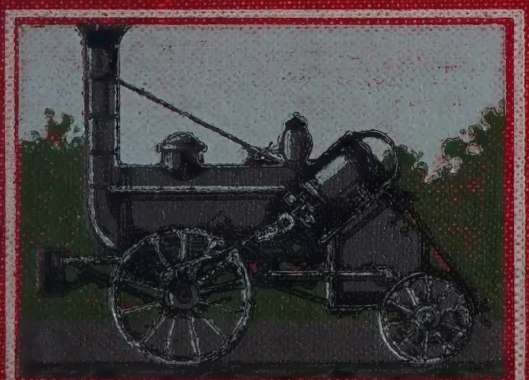
THE ROMANCE OF MODERN LOCOMOTION

ARCHIBALD WILLIAMS



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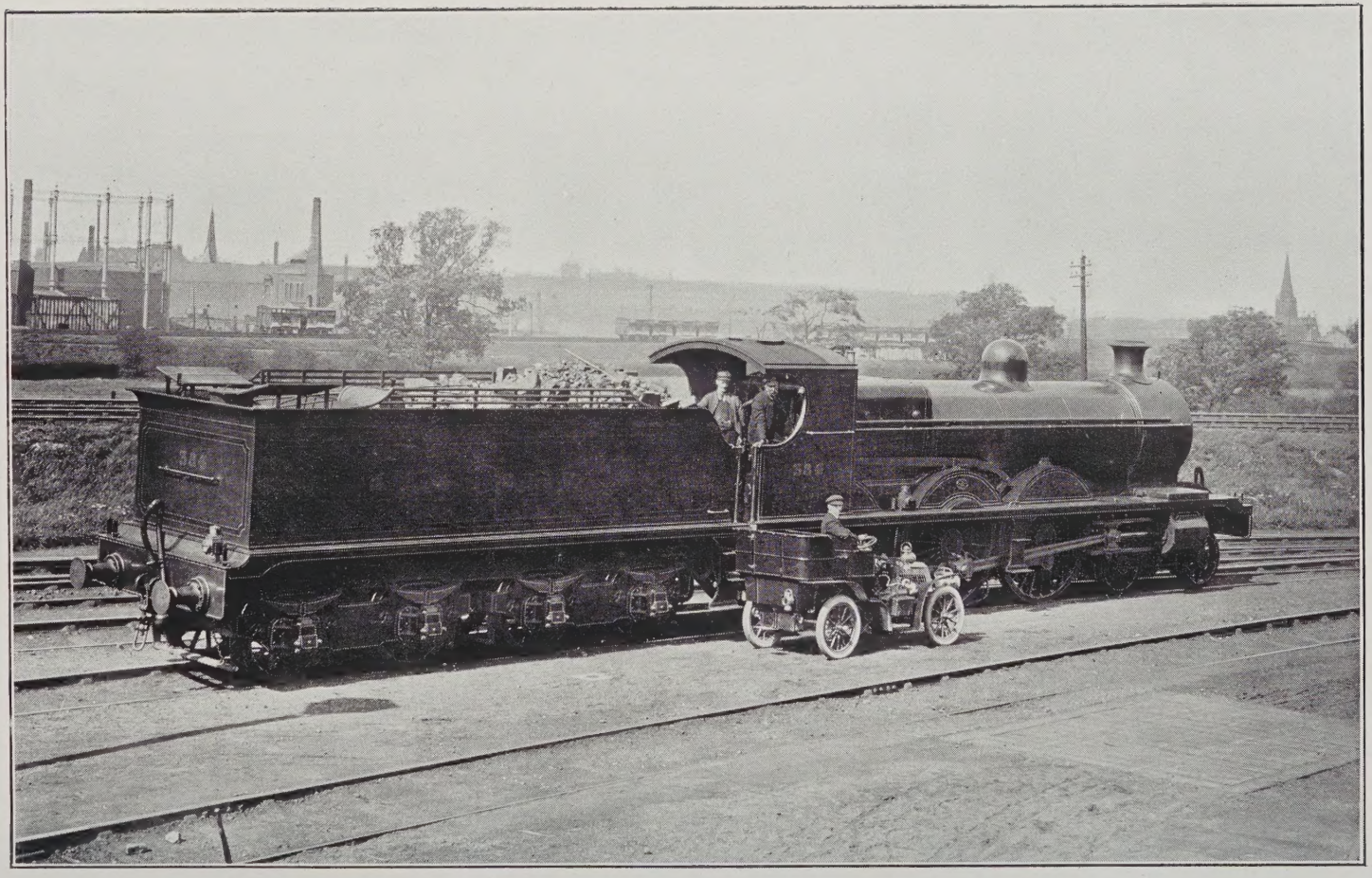

Photo by] [*F. Moore*

The Rivals.

A high-powered motor car and a Glasgow and South-Western express engine. How far will the one affect the other in the future?

[*Frontispiece*

The Romance of Modern Locomotion

Containing Interesting Descriptions (in Non-Technical Language) of the Rise and Development of the Railroad Systems in all Parts of the World

By

Archibald Williams

Author of "The Romance of Modern Invention"
"The Romance of Modern Engineering"

With 25 Illustrations

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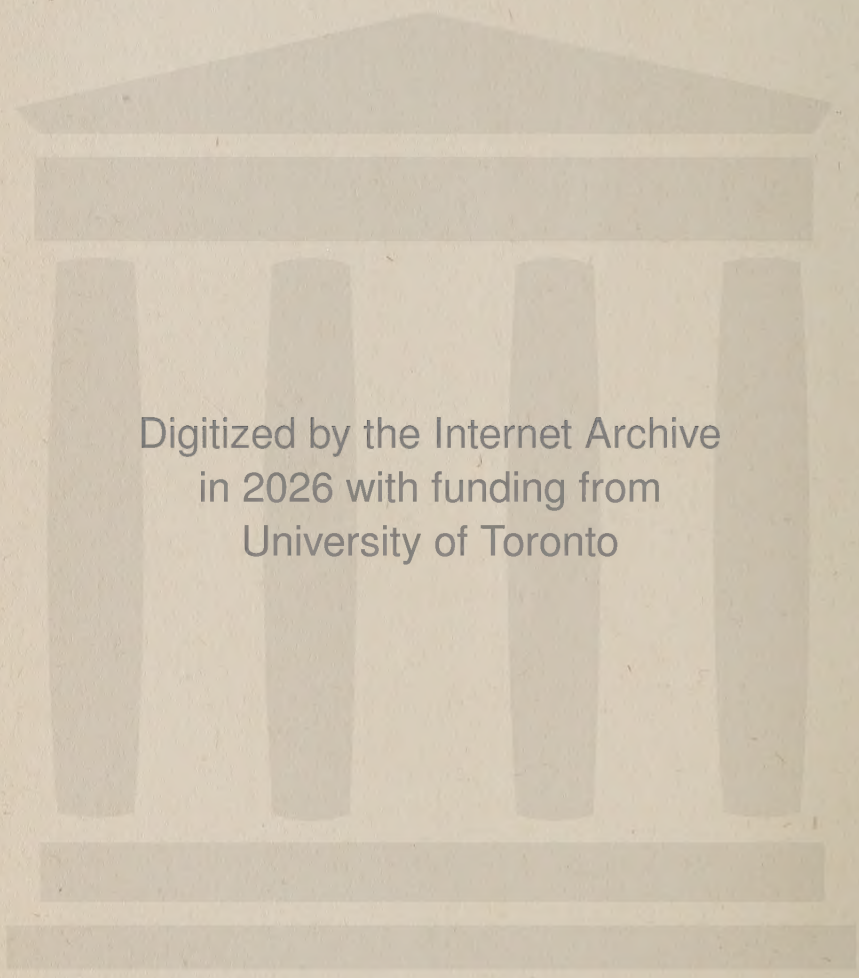
1904



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Prefatory Note

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The Romance of Modern Locomotion

INTRODUCTION

THE countryside shimmers peacefully in the summer sun. As we rest on the bridge we are aware of the murmur of insect life that fills the air, and the trim neatness of the hedges that top the cutting, and the soft background of woodland and meadow melting away in the heat-haze. But our thoughts turn chiefly to the bright metal bars that stretch beneath us and far into the distance, where a bend in the track just saves them from the appearance of converging into a single whole. The telegraph wires, gently thrumming in the light wind, whisper the secrets of the railway. The gleaming rails are silently eloquent of its life and bustle; for as the dusty road tells its story of many passing wheels, so do the polished ribbons below, fixed firmly to the well-packed sleepers, testify to the travels of the Iron Horse, that wonderful machine which, urged by the furnace flaming in its vitals, is the embodiment at once of human skill, and power, and resistless motion.

A pulley-wheel squeaks ; something has moved—the wooden arm in the distant signal. A mild excitement seizes us. We have seen the sight many a time before, but it never palls, this passing of the great express with its burden of precious human lives.

Far in the distance is a moving speck of white, which, as we gaze, expands into long tresses of snowy vapour, swept by the breeze across the emerald of the landscape. Every now and then the rattle of the train is wafted to our ears, dying down as some obstacle intervenes. She is round the curve, heading straight for us at sixty miles an hour, kept from a disastrous plunge into the banks and hedges by the inch-deep flanges of the wheels. Were but an axle to snap, or a rod to part—then what destruction ! But before the half-fear has clearly shaped itself the express is on us, enveloping the bridge in its hot breath ; and when the air is free again we see the red end of the guard's van twinkling down the rails half a mile away. The show is over ; the semaphore arm rises, moved by an unseen power ; and we are left to our thoughts.

This scene is being enacted in all quarters of the globe ; watched by the eyes of all the peoples of the earth. Let us give rein to our imaginations, and follow in spirit the express, no longer restricted by distance, but the World's Express, pursuing its headlong course across the continents. It passes now through well populated regions where snug dwellings nestle among the trees, and speak of peace and

prosperity. Now it traverses the depths of dark forests, rising threateningly on either side as though eager to step across the narrow lane cleft through them. It climbs the steep pathway blasted in the mountain side ; slides into the darkness of the tunnel where men bored and hewed for many a long month ; thunders beside the impetuous stream ; and emerges into the vast expanses of the rolling prairie. Now it crosses the hot plains of India, or the snow-clad steppes of Siberia. Here the Celestial watches it with placid eye ; there the antelope flies affrighted by its approach. It knows no impediment. A river would bar the way—a huge bridge spans the river with a network of timber or steel ; an avalanche hurls itself upon the intruder—a snow-shed reduces the sliding mass to impotence ; a great bog spreads its quaking surfaces before it—deep-driven piles pierce it to firmer ground. The express careers along, over the path that has been cunningly prepared by the engineer. Now and then Nature gets a blow fairly home, with fire or flood or earthquake ; but Man is soon on the spot, clearing and renewing: in a few days the track is open again, and the Express rolls on.

Behind it lumbers another train with a much more sedate motion, panting like an animal in sore distress. It is the World's Goods-train. As it passes we review the riches of the earth. These huge steel cars are brimful of coal mined in the deep galleries of Pennsylvania. Tanks of Texas oil ; trucks piled with the wheat of Manitoba, or the precious ores of

Ontario, or the fruit of California, or pig-iron, or timber, jostle one another. The lowing of oxen and the plaintive bleating of sheep tell of the great ranches of Argentine and Australia, that cast their millions of animals into the rapacious maw of the great cities. Now trundle past bales of cotton, wool, hides ; casks of wine ; boxes of tea, coffee, spices ; cases of hardware in its thousand forms. Five hundred million people have despatched the train ; as many await its arrival. For it and the steamship, its stout fellow-worker, are the great means of Trade which quickens the pulses of civilisation.

Hark ! as the last car swings out of sight we hear the tramp of a vast army, thousands upon thousands of men of all races and colours. At the head ride the generals, whose office it is to observe, measure, decide, direct—the Engineers. Behind come the rank and file, so many human machines, whose million arms are pitted against the wrinkled surface of Mother Earth, to fill the hollows, to hew down or cut through the hills, in the making straight of the path for the advance of the Iron Horse. Another army, as numerous as they, has been left behind in offices and depôts to guide and organise the traffic on the steel road ; while smaller detachments, sprinkled along the track, are ever keeping in due repair the work of the platelayer.

A century ago the era of the railroad was dawning. A few years later men began to ridicule and oppose the idea that a metal pathway could ever

compete in speed or convenience with the road-borne coach. Only a select number of greater minds could peer into the future when the railway would have spread its giant tentacles across the face of a country. But even they would be astounded could they see what victories the railway engineer has won, and is still winning month by month in the face of tremendous difficulties. We, on the other hand, have become so accustomed to the use of the railroad as part of our daily life that we are blinded to the true romance surrounding both the past and present of a great system. The campaigns of a mighty conqueror appeal to our imagination by the shock of arms and the manner in which history is made during a few bloody hours. The Athenian victory at Marathon, or the disastrous retreat from Moscow, are pages in human annals which can be read again and again on account of their dramatic setting, and their effects on the destiny of nations. But what about the victories of the engineer? Are they less romantic or important? Which has done more for civilisation—the battle of Waterloo, or the creation of the Union Pacific Railway? And whom should we admire most—the army of Marlborough hastening to Blenheim, or the host of platelayers daily covering the Canadian prairies with five miles of track? Let us consider the line that carries us so swiftly to our daily business in the city, or to school, or to the pleasures of the seaside and country. First, it had to be surveyed—a by no means easy task in days when every land-owner's hand

was against the surveyor. Then powers to construct it had to be wrung, at enormous cost, from Parliament. Then hundreds of men must be collected and organised, supplied with tools, housed and fed. In spite of the most careful calculations, difficulties arose in the construction which taxed to the utmost the ingenuity of the engineer ; and the spot that the train now flies over so smoothly and easily gave him many an anxious hour. The tunnels that plunge us suddenly into a few minutes' darkness represent months, perhaps years, of unremitting toil, the sacrifice of human lives, and, in many cases, the ruin of the contractor who drove them. The embankment from which we view the country far and wide has swallowed, maybe, a king's ransom before its treacherous sides could be made trustworthy and firm.

Nor must we forget the men in whose keeping we are during our journey—the telegraph clerk at the terminus ; the signalman in his lonely box ; the platelayer constantly packing the sleepers and tightening up the loose key or bolt ; and, before all, the driver, watching with unceasing vigilance for any signal of danger, and ready at a moment's notice to pull the levers that will speedily bring his charge to a standstill.

We may go further still, and think of the great workshops, replete with the most wonderful machinery, that turned out the locomotive and the comfortable carriages in which we ride ; and of the men who organise the traffic, draw out the time-bills, and see

that there is a place for everything, and that everything is in its place. We should also spare a thought for the porter, and the employé who taps the wheels, or fills the axle-boxes with grease. All are parts of a huge machine, and any falling away from duty in any one of them might mean more or less serious dislocation of the whole.

In the following pages we shall peep into the history of typical companies in Great Britain, the United States, and elsewhere ; consider the various forms of traction, signals, and other mechanical appliances connected with the working of a railway ; notice the effects of railway communication on a country for its peaceful development, or its conquest in war ; and make the tour of a typical locomotive factory. These and other matters have been treated as simply as may be, but with sufficient fulness to give the reader a fair idea of what the railway really is, how it has been made, and what the future may have in store for it.

CHAPTER I

HOW THE MIDLAND RAILWAY CAME INTO BEING

A GLANCE at the map will show that the name of this railway has been justly chosen. Starting from St. Pancras Station, London, it runs almost due north through Bedford to Kettering, then swerves to the left to Leicester, and on again northwards to Leeds, Settle, and Carlisle. If you drew a straight line from one extremity to the other, it would fairly accurately bisect England. The Midland, octopus as it is, throws out great branches from its "nerve-centre," which may be located in the area including Leicester, Derby, and Nottingham. From Derby its metals stretch southwards through Burton, Birmingham, Cheltenham, and Gloucester to Bristol and Bath, where the Great Western to London supplies the third leg of a great triangle. Westwards it reaches to Buxton, Manchester, and Lancaster; eastwards to Lincoln, Peterborough, and Hitchin, all also on the Great Northern system. Its mileage at the end of 1903 was 2284¾, which includes two long continuous runs of 320 and 308 miles to Carlisle from Bath and London respectively.

The history of this great system is most interesting, on account of its early struggles; its association with

The Midland Railway

George Hudson, the "Railway King," and George Stephenson, the engineering genius; its gradual absorption of smaller undertakings; its fierce battle with rival lines; and the "go-aheadness" which for the last fifty years has marked it as the pioneer among English railways.

Not only does the Midland Railway run through the Midlands, but it began in the Midlands. Its prime cause was the rivalry between the Leicestershire and Derbyshire coalfields. The former had been almost entirely deprived of suitable communication with the rest of England by the bursting, in 1799, of the Charnwood Forest Canal. In 1828 things had come to such a pass for the colliery owners, that one of them, Mr. William Stenson, took his levelling instruments and went over the country from Whitwick Colliery to Leicester, and approached Mr. John Ellis, afterwards the chairman of the Midland Company, with the assurance that a railway between the two points was quite practicable. Mr. Ellis, falling in with his ideas, went to see George Stephenson, then engaged on the Liverpool to Manchester line, who at first refused to undertake any further work, but who, after a dinner at a neighbouring inn, consented to go over the route proposed and give an opinion. His report was so favourable that a committee was formed for the construction of the line, and shares were subscribed, Stephenson himself taking fifty, and offering to raise any money needed in Liverpool. At the same time he refused the post

of engineer-in-chief to the new venture, and, at his suggestion, his son Robert took the berth.

The Leicester and Swannington Railway, as it was called, was begun in 1830 at Leicester. A mile from the town Glenfield Tunnel, 1796 yards long, pierced a hill. This tunnel ruined one contractor, and scared off others, so that the Company had to finish it themselves. Near Bagworth it ran for 946 yards up a severe gradient of 1 in 29, on which the rolling stock was hauled or lowered by a 5-inch cable passing round a 6-foot drum at the top of the slope. Loaded waggons descending on one set of rails raised empty waggons on the other track by gravity. At the Swannington end another incline was worked by a stationary engine and rope.

The opening of the first section of the line—Leicester to Bagworth—on July 17, 1832, was marked by the ringing of bells, playing of bands, and firing of cannon, which for twenty years or more formed an inseparable part of such a ceremony. In the middle of Glenfield Tunnel the chimney of the "Comet" collided with the roof, and broke off, smothering the occupants of the (open) carriages with soot, which they removed as best they could during a stoppage for the purpose at Glenfield Brook. The day otherwise was a success, the pace being sometimes twenty miles an hour, the dinner excellent, and the journey free from accident, except a "woman being ridden over alongside the railway by a cavalier who was trying to keep up with the train"!

The Midland Railway

The Derbyshire coal and canal owners were "hit" by this curious little single line of metals. They accordingly set to work on a rival enterprise, which should extend from Pinxton to Leicester, and so tap the Derbyshire and Nottinghamshire fields. The financiers of the projects insisted, however, that if they paid the piper they should call the tune; and the tune they wanted was a main line running from Derby to Rugby, where it would enter the London and Birmingham Railway, a branch of course going to Pinxton. When the Bill for the construction of the line came before Parliament, it was so vehemently opposed by the North Midland Company, that the Pinxton branch had to be dropped, much to the disgust of the poor coal-owners. The Act received the Royal Assent on June 21, 1836, the project being called therein the "Midland Counties Railway."

The line was built in three portions—the first, from Derby to Nottingham, was opened in 1839; the second, from Leicester to Trent Junction, in 1840; the third, from Leicester to Rugby, in 1840. In the latter year it therefore was possible to travel direct from Derby to London in two ways—either *viâ* Birmingham, by the Derby and Birmingham and London and Birmingham lines; or by the Midland Counties and London and Birmingham.

The natural result followed: a rate war between the two feeders of the London main line. But before dealing with the subject of competition, we may glance at a very interesting event in railway history—

the first organised Excursion—from Nottingham to Leicester, on July 20, 1840. The occasion was a visit of the Nottingham folk to an exhibition at Leicester. Tickets were issued at half price, and so readily taken up that the Company resolved to run a number of cheap trains. The first "placarded" train ran from Leicester to Nottingham on August 10, carrying 2000 passengers, a total not exceeded to-day. A fortnight later an even more heavily-laden train left Nottingham for Leicester.

"The engines," says the *Leicester Journal* of Aug. 28, 1840, "were overloaded, and the progress was slow. There were about 2400 persons. A special engine, with all proper means and appliances in case of accidents, was sent off to reconnoitre, but did not return. At length, about 12.30, when the excitement had almost worn itself out of long endurance, a white flag, the signal of security, was seen from the station waving in the air. The enormous train of nearly seventy carriages passed majestically in review before the astonished spectators. It was indeed a wonderful scene. Grand! magnificent! sublime! were the terms which gave vent to the feelings as in countless succession the animated mass rushed into view. It was in truth a moving city, with banners and music and accompaniments of all the material of high excitement to enhance its efficacy."

Mr. Thomas Cook, afterwards of world-wide fame as a tourist agent, first hired a train and ran it as a private speculation from Leicester to Loughborough

on July 5, 1841, for a fare of one shilling for the 25 miles.

Derby became, in 1840, the terminus of a third company, the North Midland Railway. The engineer of this line was George Stephenson, who distinguished himself by the construction of an elliptically-sectioned tunnel at Ambergate, to withstand the sliding action of a bank of shale that it penetrated. The line extended from Derby to Leeds, from which town the way now lay open to London. For the convenience of the three converging systems the Midland Counties built a large joint station at Derby, and let portions of it to the other two lines.

In 1842 Mr. George Hudson became chairman of the North Midland. As part of a special chapter will be devoted to the notorious "Railway King," the mere mention of this fact will here suffice. But the appointment had far-reaching consequences.

We may now return to the fight between the two rival lines, the Midland Counties and Derby and Birmingham Junction, for the London traffic *viâ* the (now) North-Western metals. Each accused the other of bad faith, and reduced its fares by 75 per cent. This was, of course, ruinous, and in 1842 a prominent shareholder of "Midland Counties" stock suggested an amalgamation; but without effect, as the North Midland naturally used its influence to keep the breach open on account of the advantage lying in a choice of avenues for its southwards traffic to London. In the following year things were bad for all three

companies, and rivals threatened them on the south and east, so that overtures were now made by the North Midland to the other two systems, which resulted in the amalgamation on May 10, 1844, of all three concerns under the chairmanship of Mr. G. Hudson, and the title of "The Midland Railway Company." This date, therefore, becomes one of the most important in English railway history.

The road was now clear for a policy of expansion and opposition to would-be antagonists. In 1845 an extension was opened to Lincoln from Nottingham, and in 1848 another to Peterborough from a point a few miles north of Leicester, both crossing the country threatened by the "London & York" (now G. N. R.), which had obtained an Act for construction in 1846. The building of the Peterborough line was a particularly stormy episode in railway construction. The route lay through the property of Lord Harborough, a typical sport-loving, conservative land-owner, and also the proprietor of a canal which he thought would be injured by the locomotive. The surveyors who tried to enter his grounds were confronted and driven away by gamekeepers. They collected a band of followers and returned to the attack, during which many doughty deeds were done and a good number of heads broken. Police appeared on the scene and forbade further violence. So both sides threw away their weapons and started *pushing* in the most determined scrimmage that ever took place. The contest was indecisive, and a truce

formed for a time. Then came more conflicts, in which the railway party had the worse of the fight. At last the matter was arranged, the Company being allowed to drive a tunnel under the property. Unfortunately the tunnel fell in, and a cutting became necessary. This Lord Harborough forbade. The surveyors proposed a deviation ; the owner forbade this too. And so the dispute went on, till terms were made between the two interests, and "Lord Harborough's Curve" remained for many years as a testimony to the stirring times of the 'forties.

The Midland had now got on to the future track of the Great Northern, and could give some attention to the south-west counties. The Great Western was opened to Bristol in 1841. In the previous year a line had been completed from Birmingham to Gloucester, and four years later Bristol was connected with Gloucester by a track combining the narrow and broad gauge. The "break of gauge" proved so inconvenient that a Royal Commission decided in favour of the narrow-gauge only being used. The Birmingham-Gloucester and Bristol-Gloucester companies now amalgamated, and were wooed by the Midland and G. W. R., the latter being desirous to extend its broad-gauge to Birmingham. The Midland, however, made the more generous offer. On August 3, 1846, the Midland system extended to Bristol, where its chocolate-red locomotives may to-day be seen running in and out of the Temple Meads Station.

In 1851 it absorbed the line from Leeds to

Bradford, and began to think seriously of an independent route to London. It had indeed a way thither *viâ* Rugby and the London & North-Western, but the traffic arrangements were not satisfactory. So serious was the lack of a metropolitan terminus felt to be that the two companies would have amalgamated but for a disagreement as to the respective values of the shares and the distribution of dividend among the shareholders. The Midland maintained that every £60 of their capital should be set off against £100 of the North-Western, who on their side valued a Midland share at but £57, 10s. This disagreement, trifling in itself, had most important results, since it kept the companies apart for the future to work out their fortunes separately.

Towards the north the Midland extended its sway by leasing the "Little" North-Western from Skipton to Lancaster for twenty-one years, commencing in 1852. On this line was Settle, from which they afterwards threw a track northwards to Carlisle. And towards the south the metals soon reached from Leicester to Hitchin, so opening, in 1857, a second route to London over the G. N. R.

We now come to a very interesting period of Midland enterprise. Manchester still lay outside their system, and so valuable a centre of trade must be gathered in. There already existed the short "High Peak Railway" through the Derbyshire Hills—a railway of very heavy gradients—and also a line from Manchester to Crewe, which was as much in need of

an outlet southwards as the Midland was of one westwards. The Manchester-Crewe line therefore absorbed the High Peak, and made an agreement with the Midland to connect up with it at Ambergate. But at the last moment the London & Birmingham, the Grand Junction (Birmingham to Manchester), and the Manchester to Crewe amalgamated (1846) into what is now known as the London & North-Western, leaving the Midland cut off from Manchester. The latter Company was not to be beaten, however. It decided to build a line of its own, and in 1862 introduced a Bill to connect their Matlock branch with the Manchester, Sheffield, & Lincolnshire Railway at New Mills. The Royal Assent being given, the Peak Forest district was attacked by the Company's engineers. Their chief difficulty lay in piercing the Peak with a tunnel $1\frac{2}{3}$ miles long, as the rocks were traversed internally by subterranean streams, which had to be diverted before the boring could proceed. The engineers of course surmounted this obstacle and cut a very solid, satisfactory tunnel, but soon afterward were confronted with a serious mishap in the displacement of a large viaduct at Bagsworth by an extensive landslip. The brick structure had to be pulled down and one of wood erected in its place. The Manchester route from Rugby was then open throughout.

This pushing railway had now grasped territory in all directions. One great need still remained, viz. to win independence of the G. N. R. and North-

Western as regarded the London connection. The former line had, naturally perhaps, given its own goods traffic preference over that of the Midland, and even turned Midland trucks off its system when siding room was wanted. This proved too much for the Midland Directors, who, in spite of some opposition, gained Parliamentary sanction in 1863 to bridge the gap between Bedford and the Metropolis, a distance of about fifty miles. The route selected lay through Luton, St. Albans, and Hendon, to a terminus at St. Pancras, close to and between the already existing termini of the North-Western and Great Northern railways. The gathering in of the skeins of these three systems, the Great Central and the Great Western, into a terminal area of a few square miles is, indeed, a fine instance of the fact that "all roads lead to—London"!

The Midland Directors, with wise foresight, made a track broad enough for four sets of rails, as they calculated—and correctly—that in a very short time after the opening an ordinary double track would not be able to cope with the traffic.

No London terminus is constructionally more interesting than that at St. Pancras. Probably very few passengers are aware, as they roam about the platforms, that they are walking over huge cellars, which would dismay a teetotaller by their contents and their size; but they would have noticed that to enter the station it was needful to ascend an incline to a level considerably above that of the Euston

Road. The platforms, it must be understood, are supported by a great number of iron pillars, their elevation being caused by the necessity for the line to pass over the Regent's Canal, a short distance north of the terminus. The Directors had the alternative of sending their lines under the Canal ; but as this would have entailed partly burying the station, they preferred the other course, especially as it gave them accommodation for the enormous number of beer barrels brought daily from Burton-on-Trent. In order to make the most of the room, iron pillars were used in preference to brick, and to quote the engineer's own words, "a beer barrel became the unit of measure upon which all the arrangements of this floor were based."

The station roof is as interesting as the cellars. If the reader has seen it he will probably remember its notable feature, that it consists of a single great span. The reason for adopting this form was as follows :—

If two or more spans were used there would be walls or rows of arches or pillars along their lines of junction. These would be carried by the cellar roof, which in turn would need at the corresponding points such stout supports as to destroy the uniformity of the cellar designs. Moreover, if at any future time after the opening of the terminus, a rearrangement of platforms became necessary, the roofs would have to come down and the station be remodelled. On the other hand, by using a single

span, and making the cellar roofing of uniform strength—sufficient to carry as many locomotives as could be stood upon its area—any alteration of the position of platforms would be simple. The engineer, Mr. Barlow, therefore decided in favour of a single span, 240 feet wide, with a height at the vertex of 100 feet above the rails. Although Mr. Barlow had no precedents of equal size to follow, he "made a good job of it," as a mechanic would say, a fact proved by the way in which it has stood the test of thirty-six years. This roof, by-the-bye, is 690 feet long, covers nearly four acres of platforms, &c., and cost £69,365. It is mostly screened from the view of people in the Euston Road by the magnificent hotel built after the designs of the late Sir Gilbert Scott.

Behold, then, the Midland Railway in 1868 striding from London to Lancaster, and stretching its Briareus arms to Bristol, Manchester, Rugby, Lincoln, Peterborough! Yet, like Alexander the Great, it sighed for fresh conquests; and there was still a district open to it—Westmorland and Cumberland, which lay on the road to Scotland. As already related, the Midland had secured a twenty-one years' lease of the road from Lancaster to Skipton. At Ingleton it met the Lancaster and Carlisle system, of which the L. & N.W. had a nine hundred and ninety-nine years' lease. The Midland found itself hampered as regards its Scotch traffic over these metals, in just the same way as it had suffered

London-wards, before it owned an independent route to the Metropolis. The Directors therefore determined upon another stroke for freedom—in the shape of a line from Settle to Carlisle.

The L. & N.W., of course, offered opposition, but not enough to prevent the necessary Parliamentary authorisation. The Midland was now face to face with probably the toughest piece of work in its experience. From Settle to Carlisle is 72¼ miles, through very wild and precipitous country. For 15 miles after leaving Settle the line rises on a gradient of 1 in 100 to Blea Moor Tunnel. This last is 1½ miles long, piercing grit and limestone and shale. It was driven from nine points simultaneously, seven shafts being sunk in the hills to rail level, and, on account of the somewhat treacherous nature of the strata, had to be lined throughout. For 11 miles after leaving the north end of the tunnel the line is over 1000 feet above sea-level. At Ais Gill it drops as suddenly as it rose to Ormside, passing through a succession of tunnels and cuttings, and over heavy embankments, one of which contains 400,000 cubic yards of earth. From Ormside to Carlisle the going is easier, and the work less expensive; yet nearly 3½ millions sterling had been paid out for construction before the first through train ran over Midland metals to the Cumberland county town, on May 1, 1876.

Even at Carlisle the Company's enterprises did not cease, since it was one of the chief promoters of

the gigantic Forth Bridge, opened by the (then) Prince of Wales, on March 4, 1890. This wonderful structure has been treated fully elsewhere[1] by the author of this chapter ; here the concise account given by H.R.H. in his opening speech will sufficiently detail the main features.

"It may, perhaps, interest you if I mention a few figures in connection with the construction of the bridge. Its extreme length, including the approach viaduct, is 2765 yards, $1\frac{1}{5}$ of a mile, and the actual length of the cantilever portion of the bridge is 1 mile and 20 yards. The weight of steel in it amounts to 51,000 tons, and the extreme height of the steel structure above mean water-level is over 370 feet, above the bottom of the deepest foundation 452 feet, while the rail level above high-water is $156\frac{1}{2}$ feet. . . . About eight million of rivets have been used in the bridge, and 42 miles of bent plates used in the tubes—about the distance between Edinburgh and Glasgow."

From a railway point of view the most interesting fact in connection with this bridge is the reduction of the journey from Edinburgh to Perth from 69 to 47 miles, and a saving in time of considerably over an hour. Previous to its opening trains to Perth were obliged to go round by Stirling. A great stir was made in railway circles when, in 1872, the Midland Directors announced that they would carry third-class passengers on *all* trains. Hitherto in England,

[1] In "The Romance of Modern Engineering," pp. 82–109.

as to-day in many parts of the Continent, expresses contained only first and second class vehicles, so that the poor passenger had to be content with wearisome journeys. We may imagine ourselves "third-classers" of thirty-five years ago to understand what a boon this move on the part of the Midland was to the public.

An even bolder stroke came in 1875, when the same Company proclaimed the abolishment of second-class vehicles. For the future first and third class only would be available. The second-class passenger was not left out in the cold, however, as first-class fares were reduced to the old second-class, and the third-class accommodation and comfort levelled up to the second-class standard. So that all classes benefited, as far as concerned the traveller.

Other Companies keenly resented this line of action, scenting in it an unfair form of competition. But that the course was a wise one is proved by the fact that to-day the Great Central, North Eastern, the Glasgow & South-Western, the Highland, North British, Cheshire Lines, and Caledonian have all followed the Midland's example.

This railway introduced the American train as well as the American locomotive into England. In 1874 a Pullman Car train was sent across in pieces and reassembled at Derby. At first the English public fought shy of the innovation, and insisted on having compartment vehicles; but eventually

the corridor train won its way, especially for long journeys, when the conveniences of dining and sleeping cars are added. It may be said of the Midland that, while promoting the interest of its shareholders by a policy of judicious extension, it has also found time to consult the comfort of its passengers by a series of improvements in the methods of travel.

[*Note*.—The author wishes to acknowledge his indebtedness to Mr. Clement E. Stretten's "History of the Midland Railway" for much of the information contained in this chapter.]

CHAPTER II

THE GREAT WESTERN RAILWAY; OR, THE STRUGGLE OF THE GAUGES

WHEN you think of the "G. W. R." you think of Brunel; and when you think of Brunel you have the Broad Gauge, and the Box Tunnel, and Saltash Bridge, and the *Great Eastern* floating across your mind, and know that here is a man of great ideas and great genius. The mammoth vessel is gone, and the broad-gauge is gone; but each has left behind romantic associations, and a story that loses little of its interest from being retold. The Box Tunnel and Saltash Bridge remain, silent monuments of the master's hand.

Among British railways the G. W. R. is *facile princeps* as a railway "with a past." That past terminated twelve years ago, when the last "through" broad-gauge express left Paddington for Plymouth; it began in 1833, when certain prominent citizens of Bristol determined to connect the great western seaport with London by rail. To put the matter shortly, the history of this line falls into two parts: the first witnesses the birth, growth, struggles, decline, and fall of the "B. G."; the second the triumph and reign of the narrow-gauge, which continues to this day.

Let it be understood that the standard gauge for British, American, French, German, Austrian, Italian, and Canadian railways is 4 feet 8½ inches; that for Russian, 5 feet; for Indian, 5 feet 6 inches; and in some other countries, 3 feet 3 inches. For most of the civilised world, then, 4 feet 8½ inches—the distance between the wheels of the old coal waggons on the ante-locomotive tramways—has been irrevocably adopted: whether wisely or unwisely is a much debated point.

The younger Brunel, however, made up his mind seventy years ago that so narrow a track was too restricted for the lordly locomotive. So when invited to become the engineer of the G. W. R., he spoke up for a 7-foot gauge—and got his way. Unfortunately for his decision, it came too late in the history of the railway, so many miles of the narrower track already stretched across the country north and south, east and west. It—the broad—was born into a narrow-gauge world; and the narrow-gauge throttled it, as the infant Hercules strangled the serpent; but not until the serpent had fought long and hard for its life. Few, if any, chapters of "Life on the Line" are more interesting than that dealing with this conflict.

The Great Western received its charter in 1835, and construction began the same year. By 1841 the broad-gauge had reached Bristol, whence a few years later the Bristol & Exeter Railway carried the trains to the latter city. The South Devon to

Plymouth was opened in 1846, and the Cornwall Railway to Truro in 1859. These were gradually amalgamated with the Great Western Railway, which by 1878 had a through track of its own from Paddington (London) to Penzance—all, of course, broad-gauge.

Mr. Brunel's chief reason for adopting the 7-foot gauge was that it would enable a coach 6 feet 6 inches wide to be slung *between* the wheels, which, in consequence, could be made much larger than the narrow-gauge wheels—of necessity placed under the vehicles they carried. As a matter of fact, outside wheels were employed in only one carriage built, as it soon became evident that 78 inches was much too limited a breadth for comfortable and economical passenger traffic. In 1838 a certain section of the shareholders raised objections to the broad-gauge, but Mr. Brunel in a long report stated his case so well that, on the matter being put to the vote, the broad-gauge was adopted as the standard for the main line throughout.

The chief engineering feats on the London to Bristol section were the Maidenhead Bridge and the Box Tunnel. The bridge is notable as one of the finest pieces of brickwork in the British Isles. The two main spans, each of 128 feet, have a spring of only $24\frac{1}{4}$ feet, which, in the opinion of the critics, was quite insufficient to render the arches safe for traffic. In fact, some people went so far as to say that as soon as the wooden centering of the arches

was removed, the whole structure would collapse. A storm did remove the timber work, but in spite of all the croaking the brickwork stood solid, and has been practically untouched ever since. When the G. W. R. was widened from a double to a quadruple track in 1893, Brunel's design was repeated in a bridge running parallel to the old one.

Travellers, while passing over the bridge, are probably too much engaged with the view afforded of the Thames to give thought to the track carrying them across; but the Box Tunnel cannot be thus ignored. This tunnel is, curiously enough, the first on the line, though it does not occur till over ninety-eight miles have been traversed from Paddington. It is said that on one day a year the setting sun shines through the tunnel from end to end, a distance of nearly two miles. Thirty million bricks were used to line the excavation, from which a million and a half cubic yards of matter was hewn and blasted. The westward-bound express passes through it in a couple of minutes, but an "up" train takes considerably longer, as there is a gradient throughout of 1 in 100. Yet the traveller does not, as it was prophesied in 1834 he would, experience a nausea from the transit, though to the very young and nervous there may be something rather terrific about the sudden plunge from sunlight into the rattle and roar of the dark tunnel.

The years 1844 and 1845 were a time of struggles for the broad-gauge. In 1840, as will be remem-

bered, a narrow-gauge line had been opened from Birmingham to Gloucester ; while in 1844 a broad-gauge line was opened to Gloucester from Bristol. Thus at the meeting-point there was what is termed a "break of gauge," with all the inconveniences of transhipment of goods and changing of passengers from one train to another. Ultimately, after the amalgamation of the three Companies into the Midland system, the latter bought up the Birmingham to Bristol connection, and, as soon as conditions permitted, converted the broad-gauge section to narrow. In 1845 there was a grand fight over the Bill introduced by the G. W. R. to extend the already opened Didcot to Oxford branch to Worcester and Wolverhampton. Mr. Brunel had to justify his gauge in a whole day's cross-examination. The Bill received the Royal Assent ; but not until a Commission had been demanded for an examination of the whole subject of conflicting gauges, as it was already foreseen that sooner or later there would come a time when the one would prove an Aaron's serpent and swallow the other.

Accordingly, a Commission was appointed, including the Astronomer Royal of the time and a Professor of Mathematics, at whose appointment some criticism was levelled. After evidence had been collected and sifted for seven months the verdict appeared. A few words from the concluding passages give the gist of the whole lengthy report, and may be quoted *in extenso*.

"We are led to conclude," say the Commissioners, "First, that as regards the safety, accommodation, and convenience of the passengers no decided preference is due to either gauge, but that on the broad-gauge the motion is generally more easy at high velocities.

"Secondly. That in respect of *speed*, we consider the advantages are with the broad-gauge, but we think the public would be endangered in employing the greater capabilities of the broad-gauge much beyond their present use, except on roads more consolidated and more substantially and perfectly formed than those of the existing lines.

"Thirdly. That in the commercial case of the transport of goods, we believe the narrow-gauge to possess the greater convenience, and to be the more suited to the general traffic of the country.

"Fourthly. That the broad-gauge involves the greater outlay, and that we have not been able to discover, either in the maintenance of way, in the cost of locomotive power, or in the other annual expenses, any adequate reduction to compensate for the additional first cost. Therefore . . . we are inclined to consider the narrow-gauge as that which should be preferred for general convenience; and, if it were imperative to produce uniformity, we should recommend that uniformity to be produced by an alteration of the broad to the narrow gauge, more especially when we take into consideration that the extent of the former at present in work is only 274 miles, while that of the latter is not less than 1901 miles."

Photo by] *F. Moore.*

A Group of Broad-Gauge Engines waiting to be Broken up at Swindon.

At the time of the change of gauge on the Great Western Railway in 1892 no less than thirteen miles of extra sidings had to be laid to accommodate the broad-gauge rolling stock then rendered useless until conversion.

[*To face p.* 40.

The Commissioners, nevertheless, are loth to admit that 4 feet 8½ inches is the best possible gauge. Indeed, they probably felt, with Sir D. Gooch, the G. W. R. locomotive engineer, that, if 7-foot was too wide, 4 feet 8½ inches was too restricted. It is a matter for regret that railway construction is so expensive that trials could not have conclusively settled the standard to everybody's satisfaction before the lines had ramified to such an extent as to make it almost impossible to bring legislation to bear on all the Companies. For the G. W. R. to narrow their gauge was a comparatively easy matter, as will be seen, but for the narrow-gauge people to widen theirs would have entailed the enlargement of many existing tunnels and bridges, driven and built in the first instance at enormous cost.

The G. W. R. authorities had done their utmost in behalf of their cause while the Commission was sitting. Mr. D. Gooch made what is now called a "sporting offer" to pit his locomotives against any that the narrow-gaugers could produce, and to prove where the superiority lay. Trains were to be run with 90, 80, and 70 tons behind the engines. The "enemy" stuck out for 80, 70, and 60 tons as the respective standards, and the G. W. R. Directors agreed to the reduction all round.

The stretch from London to Didcot was the scene of the Broad trials, a level length between York and Darlington of the Narrow, the distances being 53 and 45 miles respectively. We read that the Broad

locomotive negotiated the out journey in 64 minutes and the home journey in $61\frac{1}{4}$, with a train of nearly 82 tons behind the tender, and a strong wind blowing. A 71-ton train showed a little better results with $63\frac{1}{2}$ and $56\frac{1}{2}$ minutes; and a 60-tonner a further improvement with $62\frac{1}{2}$ outwards, though the inward trip took 59 minutes. The statistics are interesting as showing how easily a good engine will take an extra vehicle or two over fairly level country.

The goods train—400 tons—maintained over the same course an average speed of 24 miles an hour.

Now for the Narrow trains. They shirked the 80-ton standard altogether, and began with a 50-ton load, which travelled its course at an average of 35 miles per hour, as compared with the 80-ton G. W. R. $47\frac{1}{2}$ m.p.h. The following day, with a wind astern, the running improved to 48 m.p.h., and a 70-ton train did a 44 m.p.h. trip. It must be understood that the narrow-gauge trains had a "flying start" of 10 or 12 miles an hour, whereas the Broad started from rest. So that the G. W. R. authorities had every reason to be content with the performances of their engines, which had not, like one at least of the opposition "fliers," been built especially for the occasion.

In the face of these results, the broad-gauge advocates were not a little surprised at the Commissioners' verdict. They soon issued pamphlets to give a counterblast to those conclusions, and in 1846 had the satisfaction of receiving permission to

construct a broad-gauge line through South Wales and another from a station on the Oxford line to Birmingham, which thus became the converging point of three rival systems—the G. W. R., the Midland, and the London & Birmingham. At the same time, however, the famous Gauges Act was passed, which henceforward made it illegal "to construct any railway for the conveyance of passengers on any other gauge than 4 feet 8½ inches in Great Britain," though exceptions were made in the case of any future connection between the South Wales Railway and the city of Bristol, the Oxford, Rugby, & Wolverhampton Railway, and any connection of the G. W. R. that should be built *south* of the main line. The narrow-gauge party gained a further victory in 1848, when they persuaded Parliament to compel the introduction of "mixed" broad and narrow gauges on the Oxford-Birmingham line. The G. W. R. authorities decided that the mixture should be effected by laying a third metal for narrow vehicles, the outside, or platform, rail being common to both gauges. Little by little the length of "mixed" line increased. On October 1, 1861, the first narrow-gauge train left Paddington station, bound for Birmingham, and by 1874 "narrow" metals extended to Exeter, where transhipments had to be effected for the South Devon and Cornwall stretches, which remained pure broad till their final conversion to narrow in 1892.

Though a special chapter has been reserved for

a description of typical locomotives, mention should here be made to the broad-gauge engines designed by Mr. D. Gooch in 1846, and following years, as a set-off against the improved narrow-gauge engines being then introduced by Stephenson and others. The first locomotive of the series, the "Great Western" was built in thirteen weeks at the G. W. R. works. It had cylinders of 18-inch bore and 24-inch stroke, fed from a boiler with 1751 square feet of heating surface. The driving wheels were 8 feet in diameter, and the engine and tender together weighed 45 tons.

This fine locomotive soon attracted attention. Mr. G. A. Sekon, in his interesting "History of the Great Western Railway," writes (pp. 184 foll.):—

"One of its first remarkable trips was from Paddington to Swindon and back with a train of fourteen carriages, weighing 140 tons, the entire journey performed at an average travelling speed of 57 miles an hour. On another occasion she took the 9.45 A.M. express from Paddington to Exeter, 193¾ miles, in 3 hours 28 minutes, or at the rate of 53 miles an hour for the whole journey. On Saturday, 13th June, 1846, a sensational trip was made. . . . The train (the 'Great Western') weighed 100 tons, and consisted of ten first-class carriages, seven of which were ballasted with iron, the other three being occupied by the Directors and those interested in the experiment. The train started from Paddington at 11 hours 47 minutes 52 seconds; at Didcot a stop of 5¼ minutes was made; Swindon was reached

in 78 minutes. After staying there 4 minutes 27 seconds the journey was continued to Bristol, the whole distance of 118½ miles being covered in 2 hours 12 minutes, or at the rate of 54 miles an hour, or, excluding the 9¾ minutes spent in the two stoppages, at about 59 miles an hour for the complete journey, including the slowing down and getting up speed again on three occasions."

The best bit of travelling recorded on this trip was 10 miles in 9 minutes 8 seconds, or 66 miles an hour.

These times were considerably beaten in 1851, when an express ran regularly from Paddington to Slough (18 miles) in 15½ minutes, or over 70 miles an hour! To-day the best long-distance time on the G. W. R. is to Bath (107 miles) in 1 hour 47 minutes, or just 60 miles an hour. It should, however, be remembered that the train-weight has increased considerably since the 'forties. It is on record that in these early days an engine-driver offered to take his engine from London to Bristol in *one hour* if the Company would provide for his wife and family in case of the run coming to a disastrous conclusion! The offer was naturally refused, though probably more than one of the Directors secretly wished that circumstances would justify such a trial.

Besides being speedy, they were tough, these old "broad-gaugers." One of them, the "Lightning," during a merry life of thirty-one years, covered 816,601 miles; while nearly a dozen more of the

same class exceeded 700,000 miles before being "mended with a new one."

The South Devon Railway, extending from Exeter to Plymouth, is interesting on account both of the route it follows along the seashore near Dawlish, and of the manner in which Brunel decided to propel trains over its metals—by the atmospheric system.

From Exeter the railway runs almost due south along the river Exe for about ten miles, then, turning south-west, follows the seacoast another ten miles to Teignmouth, and the estuary of the Teign five more miles to Newton Abbot. It then makes a long inland reach westwards over broken country for the remaining thirty odd miles to Plymouth.

To Teignmouth the line is practically level, but it necessitated considerable embankments, sea-walls, and tunnelling. At Dawlish the railway embankments run between the sea and the town, which is thus cut off from a good view of the rolling waves.

The railway to Newton Abbot was opened in 1847. Along the track ran a fixed iron pipe having on the top a longitudinal slit closed by a valve of leather. One carriage of the train was provided with an arm projecting downwards and passing through the slit into the tube, where it terminated in a piston. At the extremities of the line stood large pumping engines to exhaust the air from the tube on that side of the piston facing the direction in which the train was to travel. The vacuum thus produced caused the air on the other side of the

piston to exert a pressure of nearly fourteen pounds to the square inch, and the impulse transmitted by the arm to the carriage was sufficient to propel a light train at as high a speed as 70 miles an hour. In order to maintain a vacuum in the tube, it was, of course, necessary that the slit should be closed by a flexible tongue of leather that would allow the passage of the arm, while admitting a minimum quantity of air.

On January 10, 1848, "all the trains except the first and last each way commenced running by atmospheric power, and the trial fully answered all the expectations. Notwithstanding the disadvantages attending the commencement of every new undertaking, not a single instance of stopping or delay occurred on the new piece of road from Teignmouth to Newton. On the first day the express train was unusually heavy, and it started from Newton six minutes after its proper time, but reached Exeter at the regular period, gaining six minutes on the 20 miles. On the 12th the down express train was thirty minutes late at Exeter, but on arriving at Newton ten minutes had been recovered—so much, therefore, in praise of the system." On 29th February the general meeting of the Company was held, and the Chairman then stated: "The atmospheric had proved so successful that the locomotive had been entirely withdrawn from the line between Newton and Exeter. Out of 884 trains which had then been run, 790 had either gained time or performed the

journey in the exact time. Of the remainder, 70 lost from one to five minutes, 14 from six to ten minutes, 3 from eleven to fifteen minutes, and 7 from sixteen minutes and upwards."[1]

All this sounded very satisfactory, and we may imagine the disgust of the shareholders when, at the end of the first six months of 1848, the Directors announced that, as the result of a report by Mr. Brunel on the condition of the atmospheric system plant, they had decided to replace it by steam locomotive power! The longitudinal valve, upon the proper action of which depended the possibility of maintaining a vacuum in the piston tube, had been so deteriorated by but a single year's traffic that it required renewing, at a cost of £1600 per mile; and the Directors, rather than face the yearly repetition of such a charge, preferred to sacrifice the hundreds of thousands of pounds already expended. That they were justified in their decision is now evident, since on no line where the atmospheric system has been installed has it not ultimately given place to the locomotive. In this case the abandonment must have come when the South Devon and Great Western lines amalgamated, seeing that a "break of propulsive system" would have proved inconvenient for all through traffic.

The Cornwall Railway, from Falmouth to Plymouth, was not opened till 1859. It contains one peculiarly interesting engineering feat in the great

[1] Mr. G. A. Sekon's "A History of the Great Western Railway."

suspension bridge which crosses the Tamar estuary near Saltash. In the designing of this bridge Brunel fully regained the reputation lost over the "atmospheric" fiasco of the South Devon Railway.

The two main spans of the bridge are each 455 feet long — only 5 feet less than the spans of Stephenson's famous tubular bridge over the Menai Straits. These rested on three masonry piers, two of which were built up from foundations in the shallow water at the estuary sides, the third rising from a point in mid-channel. To make a firm foundation for the central pier it was necessary to pierce deep mud down to hard rock by means of a circular caisson 35 feet in internal diameter. This was gradually sunk until its lower edge rested on the greenstone bed of the river ; and as soon as the mud had been cleared out and all influx of water stopped, the masons bonded in the lowest course of granite ashlar work, and built up to a point 12 feet above high-water level. The top part of the caisson was then removed in two parts, leaving the masonry exposed to view.

The great trusses for the main spans were a combination of arch and suspension chains, the outward thrust of the former exactly counterbalancing the inward pull of the latter. The track platform was attached to both elements by vertical bars.

After being built on land the trusses were launched on iron pontoons and in turn warped, by means of ropes and chains, into position over the pier foun-

dations. The pontoons were then sunk sufficiently to let the truss ends down on to the piers. At each extremity three very powerful hydraulic rams lifted the truss a few feet at a time, while the masons built in the gap. The jacks were then placed on the top of the new course, and the process was repeated until the full height had been reached. The Royal Albert Bridge, as it was named after the Prince Consort, was opened on May 3, 1859.

The important South Wales line, joining the Great Western Railway system at Bristol was first put into direct communication with London on September 5, 1885, when a train passed through the famous Severn Tunnel carrying the Chairman of the Great Western and a party of friends. This, the longest tunnel in the British Isles, runs for a distance of $4\frac{1}{2}$ miles under the Severn bed between Sudbrook in Gloucestershire and Portskewett in Wales. The difficulties of constructing the tunnel may justly be described as enormous, owing to the inrush of fresh water from subterranean springs, and an incursion of the sea after an exceptionally high tide. Mr. T. A. Walker, the contractor for the main part of the work, considered that "one such tunnel was sufficient for a single lifetime." The tunnel consumed over 77,000,000 bricks for its 27-inch thick lining, and the laying of these occupied fourteen years. Though the "headings" had to be driven from both sides of the river on a falling gradient to a short level stretch under the bed, the calculations were so well worked

out that "no deviation from absolute straightness could be detected by instruments." [1]

Years before the completion of this, the most important of all the G. W. R. engineering achievements, the doom of the broad-gauge had been foreshadowed. In 1868 the line between Wycombe and Aylesbury in Buckinghamshire was converted to narrow-gauge. Then every year saw more conversions made on the branch lines to Oxford from Maidenhead, from Oxford to Wolverhampton, Didcot to Oxford, Bristol to Milford, Twyford to Henley—hundreds of miles in all. The final doom of Brunel's gauge came in 1892. On May 20, 1892, the last broad-gauge train left Paddington for Penzance. It has been said that there is something sad about doing anything for the last time. And no doubt it was a feeling of genuine sentiment which on that day attracted a crowd to the London terminus to witness the closing of the last chapter in broad-gauge through traffic. At all the principal stations on the route farewell cheers were sent after the train as it swung out of the platforms.

Now followed the conversion of the 106¼ miles from Truro to Exeter and the western broad-gauge connections. In order to reduce to a minimum the dislocation of traffic, arrangements were made whereby an army of over four thousand men was distributed over the scene of operations. Every detail had been thought out carefully; each man knew exactly what

[1] *Vide* "The Romance of Modern Engineering," chap. xi.

he had to do. At daybreak on May 21, 1892, the work began of slewing the inside metals 28½ inches towards the outside of the track. By nightfall the broad-gauge was dead: the moved rails had not, of course, been permanently fixed in position, but narrow-gauge trains could now pass from Paddington to Plymouth. Two days later the great army dispersed.

Since 1892 the Broad metals of the mixed-gauge portions of the main line have been removed, and the longitudinal replaced by transverse sleepers, which are said to give more elastic running, and are certainly more convenient to handle than the heavy timber baulks carrying the broad-gauge. Here and there, in sidings, one may still see the old "mixture," a memento of the Great Western's youth.

CHAPTER III

THE BUILDING OF THE CANADIAN PACIFIC RAILWAY, THE GREAT CANADIAN HIGHWAY

IN Canada, as in the United States and Siberia, the origin of the first transcontinental line was political. As long ago as 1847 Major Carmichael Smyth urged upon the Government the necessity of creating a great national highway from the Atlantic to the Pacific, to supply the last link in the chain round the world, uniting the English race by land and sea.

The Grand Trunk line had already opened communication by rail between Upper and Lower Canada and the United States. When, in 1871, British Columbia entered the Confederation of Canadian States, it was felt that mere political union would be but a weak bond, unless ready access to the Pacific seaboard were possible from the older states. During the previous year the difficulty of quelling Louis Riel's rebellion on the Red River—only half-way across the continent—on account of the lack of means of transport, had brought home to the Government the fact that without a railroad the remote province on the Pacific would be very vulnerable in the event of war. It was also insisted, on the part of Columbia,

that, as a condition of entering the Confederation, a railway should be thrown right across Canada.

The carrying out of so gigantic a task fell upon the Government, and the Premier, Sir John Macdonald, promised that the line should be completed in ten years. On July 20, 1871, the surveys were commenced in British Columbia, as they had already been on other portions of the route ; and before the end of the year a practicable line had been discovered over the whole distance from Lake Superior to the Pacific. In order that the best possible path should be taken by the rails through the difficult country of the Rocky, Selkirk, Gold, and Cascade mountains on the west, and the Laurentian ranges round Lake Superior, the surveyors were hard at work for the next six years, on a task that cost the Government £750,000 sterling. Engineers explored the mountain passes in all directions, experiencing the hardships and dangers inseparable from travel in wild, icebound country, fissured by huge chasms, along the side of which they had to creep, and flanked by towering peaks that hurled down devastating avalanches. The adventures of these pioneers, thrilling and varied, are enough in themselves to fill a book, and, did space permit, might here be added as a most interesting chapter in the romance of the railway.

The task before the Government was as follows: to construct 2500 miles of new line, 650 of which—between Ottawa River and Port Arthur, on Lake Superior—lay through a district notorious for its

unsuitability for railway construction. From Lake Superior to Winnipeg, on the Red River, the country was also difficult, and west of Winnipeg the Prairie section stretched 900 miles to the Rocky Mountains, a territory which, so far from being of the billiard-table levelness of popular imagination, contains very little level ground. The west mountain section, through the Rockies to the Pacific, promised to strain the resources of the engineer to the utmost.

The early fortunes of this railroad varied with the political party in power. When Conservatives held the reins of office, they turned to private enterprise to help them lay the track ; when the Liberals ousted them, it was discovered that Government, and Government alone, should conduct operations. As a result of this shifting and changing, actual work was not begun till 1875, and then only at the Lake Superior end, no progress being made from the Pacific side till 1879.

In the latter year the Conservatives returned to power, and things "began to move." Private persons were called for to undertake the completion of the track. Several gentlemen came forward—Messrs. J. J. Hill, R. B. Angus, J. S. Kennedy, G. Stephens, and Duncan M'Intyre, backed financially by Messrs. Morton Rose of London, and Messrs. Cohen & Reinach of Paris, "the seven concessionaires of the longest and most important railway that has yet been handled by one syndicate." The essential conditions of the contract were :—

That the Company should receive 25,000,000 dollars in cash, and an equal number of acres of land in the fertile belt, in addition to right of way for track and stations, shops, docks, &c., on public lands.

That all materials used in the first construction of the road should be admitted duty free.

That the Company's lands should be perpetually exempt from taxation.

That the sections of line under contract—about 700 miles, which had cost 30,000,000 dollars—should be completed by the Government and handed over as a free gift to the Company.

The Canadian Pacific Railway Company on its side contracted to have the line open for traffic by May 1891, and to observe a standard of construction equal to that of the Union Pacific road in 1873. Later on, when the Company found itself compelled to apply to Government for a loan of six million pounds, the date was altered to May 1886.

On February 17, 1881, the C. P. R. Act received the Royal Assent, and the Company its charter. For the fulfilment of the contract, over 400 miles of rail must be laid each year; and in order to make this possible, work was commenced simultaneously at several points—on Lake Superior, at Ottawa, and at Winnipeg, westwards, and from the Pacific coast, eastwards.

The Company's chief energies were first concentrated on the section between Winnipeg and Calgary

Photo by] [*Canadian Pacific Ry. Co*

The Entrance to the Rockies on the Canadian Pacific Railway.

The line climbs over the lofty range in the background, through scenery that can scarcely be matched for its beauty.

[*To face p.* 56.

in the Rocky Mountains. It was decided to abandon the route mapped out originally by the Government surveyors north of Lake Manitoba and through Edmonton and Pine River Pass, and to follow a track some hundreds of miles further south through the Rockies ; also to construct the line in a more substantial manner than the contract required.

The earthwork on the "prairie section" averaged some 17,000 cubic yards per mile, and, in order to avoid snow-block as far as possible, the railway ran along embankments.

Between May and December 1881, 165 miles were driven west from Winnipeg. The following year, to quicken operations, a contract was made by the Company with Messrs. Langdon & Shepherd, of St. Paul, Minnesota, to complete the line to Calgary. The contractors at once advertised for labour, offering 8s. 4d. per diem to navvies, and 19s. for two horses and a driver. They also sublet the work in sections, of a length varying with the ability and means of the contractor.

A vivid account given of the work on this section in the columns of *Engineering* will enable the reader to form some idea of the completeness of the organisation required to lay 500 miles of rail in a single year.

"The rapidity of construction of this section of the road is without a parallel in this or any other country. Where there was neither timber nor building stone all the materials had to be transported from 700 to

1500 miles, and even the food and the commonest necessaries for the consumption of the men and the horses had to be brought on an average 1000 miles, as the whole country west of Winnipeg was too new and unsettled to supply the simplest want. It was important that none of the sub-contractors should undertake more than they could accomplish within the specified time, and of the sixty parties employed, and over three hundred separate contracts let on the prairie section of the work, only twice was there any delay in this respect, or where the firm had to complete the work themselves. As soon as a gang had finished one section, they had to move from 100 to 150 miles ahead to their next location, where in another six weeks they were tolerably sure to hear the locomotives behind them, and the clanging of the hundred hammers of the platelayers close at their heels.

"In advance of the track-laying party were two bridge gangs, one working night and the other in the day, and as every stick of timber had to be brought from Rat Portage, 140 miles east of Winnipeg, they were seldom more than eight to ten miles ahead of the track-layers. The timber had to be hauled from the point where it could be unloaded, as near to the end of the track as possible, to the place where it was wanted, and this was generally done in the night to interfere as little as possible with the other work. Where not a stick of timber nor any preparation for work could be seen one

day, the next would show two or three spans of a nicely-finished bridge, and twenty-four hours afterwards the rails would be laid and trains working regularly over it. Following these came the track-laying gang, the most attractive and lively party of the lot, and on which most of the interest of those who visited the work seemed to centre. There were three hundred men with thirty-five teams in this gang. Moving along slowly but with admirable precision, it was beautiful to watch them gradually coming near, everything moving like clockwork, each man in his place, knowing exactly his work and doing it at the right time and in the right way. Onward they come, pass on, and leave the wondering spectator slowly behind whilst he is still engrossed with the wonderful sight. The returning locomotive, with her long string of empty cars rushing past him, awakens him from his reverie, and another, pushing before her more slowly her heavy load and taking them up to the front, shows him that where an hour before there was nothing but the upturned sod, two ditches, and a low embankment, there is now a finished working railway, and that the great Pacific highway is a fixed fact before his eyes. The emblem of civilisation has passed, the subjugation of the land is accomplished, and that which was the hunting-ground of the Indian and the home of the buffalo yesterday, has gone for ever from his occupation, is Britain to-day, not in name only but in use, and will probably be occupied within a week by

some hopeful and happy British family, who in another season or two will make it a smiling home, and the abode of lasting comfort and prosperity. No wonder that it was a sight that hundreds came to see; it was a miracle of progress, the visible growth of an empire, the practical realisation of the dream of centuries, as the highway was gradually being laid down destined to conduct the commerce of Europe to that wonderful Orient where a prodigal Nature pours out her riches to supply the wants and luxuries of the world. All that Columbus and Champlain and others had hoped to discover, all that Magellan and Hudson and Franklin had died to find out, all that England and Spain had bestowed their money to explore, and all that France had lavished her energies and sacrificed her heroes to control, was quietly being accomplished by that motley gang and those few locomotives as the north-west passage to Asia was being gradually laid down over these hitherto unserviceable prairies. Each day from twenty to twenty-five 20-ton cars of rails and fastenings, and from forty to fifty cars of ties and other materials were laid down by this busy track-laying gang, and nearly all of this had come an average of 1000 miles by rail before it was safely delivered at the 'end of the track.'"

Under these conditions it is not surprising to learn that in 1882 no less than 349 miles of finished railway was laid, in addition to 110 miles of grading in advance. For some months operations were sadly

delayed by the disastrous floods on the Red River; and in order to make up for lost time some extraordinary work was witnessed during the last six months of the year, during which rail-head advanced at the rate of nearly two miles a day. Even this record was eclipsed in 1883, when for several weeks on end $3\frac{1}{2}$ miles of track were completed daily, the finest record, that of July 28, being quite unsurpassed in railway construction.

On that day $6\frac{1}{3}$ miles were laid. This is how the writer already quoted describes it:—

"There were twenty-four men to handle the iron, that is, twelve unloading it from the cars, and twelve to load the trollies. It took the same number to lay it down in the track. The total number of rails laid that day was 2120, or 604 *tons*. Five men on each side of the front car handed down 1060 rails, 302 tons each gang, whilst the two distributors of angle-plates, and bolts, and adjusters of the rails for running out over the rollers, handled 2120 rails, 4240 plates, and 8480 bolts. These were followed by fifteen bolters, who put in on an average 565 bolts each; then thirty-two spikers, with a nipper to each pair, drove 63,000 spikes, which were distributed by four peddlers. The lead and gauge spikers each drove 2120 spikes, which, averaging four blows to each spike, would require 600 blows an hour for fourteen hours. There were 16,000 ties or sleepers unloaded from the trains, and reloaded on to waggons by thirty-two men, and thirty-three teams

hauled them forward on to the track, averaging seventeen loads of thirty sleepers to each team. On the track eight men unloaded and distributed them, and four others spaced them, two others spaced and distanced the joint ties, and two others arranged and adjusted displaced ties immediately in front of the leading spikers. Four iron carboys and two horses were used to haul the iron to the front. The first two miles of material were hauled ten miles along the prairie, and the rest from three miles up, as the usual side track gang put in a siding two thousand feet long during the day."

To feed the army of 9000 men at work on the prairies over 150 miles of country was in itself a heavy task. The horses consumed 1600 bushels of oats a day, and the men required the contents of two 35-foot trucks to keep them in condition for their severe labours. There was no underfeeding or bad provisions. In 1893 a thousand cattle died in the prairie slaughter-houses; three hundred sacks of flour were distributed among the army of navvies, who lived well on a generous variety of food. The camps were well policed, and the ruffianism that was so common on the great railroads of the United States, was here practically unknown, thanks to the strict prohibition of all intoxicating liquors among the workmen. All trains were carefully examined for contraband goods. If a man was detected importing liquor, he lost his property and fifty dollars. A second offence meant

a 200-dollar fine; on the third occasion it was doubled, and he was ornamented with a ball and chain on one leg. The fact that such magnificent work was done in Canada without the aid of alcohol is a serious blow to the claims put forward by a large portion of the community in this and other countries on behalf of the valuable properties of strong drink as a help for hard physical labour.

On August 15, 1893, the rail-head reached Calgary, and Messrs. Langdon & Shepherd's men were transferred to a fresh contract to penetrate the Rockies. In three seasons 962 miles had been laid between Winnipeg and these mountains. Meanwhile progress was being made in other sections. In British Columbia an army of 7000 Chinese hacked and hewed its way through the Cascade Range, and as many more labourers were busy between Winnipeg and Ottawa, breaking down, with thousands of tons of dynamite, the tough Laurentian and Huron rocks. Along the northern shore of Lake Superior the amount of blasting to be done made it worth while to establish dynamite factories on the spot. A single mile of tunnelling by the lake side is said to have cost three quarters of a million sterling. It was fortunate that, in spite of natural obstacles, the work was energetically carried out, winter and summer alike, since in the spring of 1885 Louis Riel, at the head of a band of malcontents, raised a second rebellion in the far North-West, which was quickly crushed on account of the

speed with which the nearly finished railway enabled the militia to arrive on the scene of action. Very shortly after this rebellion the line stretched continuously from Montreal to the summit of the Rockies.

The latter had been reached at the end of 1884, and the engineers paused awhile to consider the merits of the various routes open for the descending gradients on the Pacific slope. One of these, the Howse Pass, offered comparatively easy gradients, but it would have added thirty miles to the length of the line. The Kicking Horse Pass, on the other hand, was short but steep, and in order to complete the transcontinental track without loss of time, the engineers decided to build a temporary line through the Kicking Horse Pass, and replace it later on by the more circuitous but gentler gradients of the Howse Pass. "In the 44 miles between the summit of the Rockies and the mouth of the pass in the valley of the Columbia River, a fall of 2747 feet was accomplished, and in that distance, in addition to other minor streams, the Kicking Horse River was crossed nine times, and, exclusive of tunnels, 1,500,000 cubic yards were excavated, 370,000 of which were of rock. The drilling for this, owing to the impossibility of conveying machinery to the spot, was done by hand. In one part treacherous landslips gave far more trouble than even the hardest rock." [1]

[1] *Quarterly Review*, 1888.

Photo by [*Canadian Pacific Ry. Co.*

Imperial Limited (C. P. R.).

The great Trans-Canadian express which covers the 3,096 miles from ocean to ocean in 96 hours.

[*To face p.* 64.

The Canadian Pacific Railway

Early in 1885, while the eastern sections of the C. P. R. were being linked up round Lake Superior, a gap of only 220 miles remained in Columbia. But across the gap stretched the Selkirks and the Gold Range. The former had proved almost impenetrable even to the surveyors, and when at last Major Rogers, the Company's engineer, acting on the advice of a Mr. Moberley—who in turn had got a hint from the flight of an eagle—discovered a practicable path, the platelayers were hard on his heels.

The two parties finally met in Eagle Pass, in the Gold Range. Before the last few miles had been laid the first transcontinental train was despatched from Montreal, on what was confidently expected to be an unbroken journey to the Pacific. On November 5, 1885, a day that should go down to posterity as marking a critical event in Canadian history, the last rail was laid, and the last spike driven, in a lonely forest glade at Craigellachie. There was no ceremony, no feasting or speech-making to mark the event. The last spike was no golden one, such as closed the Northern Pacific plate-laying in the presence of a large multitude, but of plain iron like the millions of others that had preceded it. It was hammered in by Sir Donald Smith, a dozen or so persons looking on, and then the small party went off to fish, just as if the completion of so gigantic a work were quite an ordinary occurrence! But meanwhile the news was flashed over the wire spanning mountain and

plain. The whole world knew that the line was open six months before time!

Thus in four years and a half 2200 miles of rails had been laid, in a solid and substantial manner. At only one point between Montreal and Winnipeg does a gradient exceed fifty feet to the mile. Though there had been no obstruction from hostile Indians, such as had hindered the railway extension in the States, the route on the whole lay through difficult country. The C. P. R. has a distinct advantage over the Northern Pacific and Union Pacific systems as regards the altitudes reached by its rails. The highest point above sea-level on the C. P. R. is 5296 feet, as against the 5563 of the Northern Pacific and the 8240 of the Union Pacific. As a transcontinental route it has also in its favour the fact that but 2906 miles separate Montreal and Vancouver, as compared with the 3271 miles between New York and San Francisco. Since the St. Lawrence is open for traffic during the summer months only, the Government brought into being a line, known as "The International," to connect Montreal with the British ports of St. John in New Brunswick and Halifax in Nova Scotia, which all the year round would give a clear run from the waters of one ocean to those of the other, the St. Lawrence being crossed by a magnificent bridge at Lachine.

The political importance of the Canadian Pacific Railway can hardly be overestimated. It supplies

England with an alternative route to those *viâ* the Suez Canal and the Cape, by which she may send troops to India or the Far East. In event of war the canal might easily be blocked by a single hulk, and the Cape route be rendered dangerous by privateers. But the Atlantic tracks to Canada could be kept open by her powerful navy for the transports. Once on Canadian soil, the forces would be whirled by express to the Pacific coast—where is a naval station at Esquimalt—and be prepared to embark for India, or to return, in case of need, to England. In war time, too, Britain's great granary will be the Canadian provinces, now all tapped by the 10,000 miles of the C. P. R. system, as cargoes from Russia, India, New Zealand, South America, and the United States could not be escorted. The time may come when the long steel ribbon stretching across the old territories of the painted Indian will prove the salvation of the British Empire.

CHAPTER IV

WHAT THE CANADIAN PACIFIC RAILWAY HAS DONE FOR CANADA

At some periods in the dim ages before man appeared to lord it over creation, the part of North America now known as Canada was the scene of titanic upheavals. On the west, in Labrador and Ontario, rose the Laurentian Mountains, hard and crystallised, but pregnant with mineral wealth incalculable. As years—centuries—passed, vegetation gradually clothed the slopes of the depressions which contain the great lakes, and the mighty cleft through which the St. Lawrence flows. Two thousand miles further west the earth's crust, propelled by some enormous internal energy, pressed eastwards, causing the Rocky, Selkirk, and other ranges to rise like the folds of a cloth pushed across a table. Between the two great mountain systems of Canada stretched—so the geologists tell us—a great sea, which in the course of time disappeared, leaving as a memento of its existence a rich earthy deposit, many feet deep. On this grass grew; and to eat the grass came the buffalo; and to kill the buffalo, the Indian; and, finally, the white man to oust the Indian. At first the whites were few, and

the Indians many, and it took a century of continuous skirmishing and massacre to prove which was the stronger. But, as usual, the lighter colour prevailed; the Indian withdrew further and further westwards with his mustangs and squaws, and the European pressed past the lakes into the great plains beyond.

They were hardy men, these early settlers. Except for Nature's waterways, roads there were none. Each settler made a small clearing if he found forest, and sowed his grain, to discover in a year or two that the land which would grow trees and grass was good for corn also. So he called in his friends, and they followed his example, till gradually the provinces of Manitoba, Assiniboia, and West Ontario were dotted over with farms, set far apart on the rolling prairie.

One day a small band of newcomers arrived on the edges of the plain, armed with stakes and flags and queer-looking instruments. They made observations, and stuck in the flags, and went on. A few years later came a large band of railwaymen, digging, levelling, scooping, and laying the bright steel rails that were to run from the eastern provinces right across to where the fertile belts of British Columbia nestled between the stern Selkirks and the Pacific Ocean.

The railroad track was but a few feet wide, and a few feet higher than the plain. It could not be termed imposing in any way, in the plain region. Yet its presence foreboded a great change in the lands

through which it passed. Before the last spike had been driven in the far-off Columbian forest a train drew out from Montreal, heading for the western seas. Ever since 1886 the locomotive has flashed backwards and forwards, depositing human freights at many points on the way. Where the forest once waved, may now be seen smiling cornfields ; where the lonely settler beheld uninhabited prairie to the horizon, busy towns pant and throb. The railway has done it all, this wonderful track, wonderfully built in a few short years. One more channel has been cut, through which large populations may overflow into the hitherto waste portions of the earth. It is no exaggeration to say that since the opening of the C. P. R. the prairie has been turned into a garden, amid which towns, villages, and hamlets have sprung up and flourished on the scenes of the pioneers' early hardships. The Canada of to-day is not, of course, the Canada of fifty years hence, when the hamlet will in turn have become a town ; but it is such as would have astounded the old Frenchmen who first looked upon it, had they possessed prophetic vision.

To grasp the real meaning of the Canadian Pacific Railway as a maker of history, let us in spirit pass over its metals and see what we can see.

In the summer you may reach the western terminus, Quebec, by boat direct ; but in winter, when the ice has blocked the river, you disembark at the old city of Halifax, and are spun across New

Brunswick and Maine to Montreal, where the British, in the palmy days of the Hudson Bay Company, established a flourishing headquarters for the fur trade. Now it rises from the broad St. Lawrence to the slopes of Mount Royal (Mont Royal = Montreal), and looks over a densely-peopled country, dotted with bright and charming villages—a large and beautiful city, half French, half English ; half ancient, half modern ; with countless churches, imposing public buildings, magnificent hotels, and tasteful and costly residences. Its trade is shown in the long lines of warehouses, grain elevators, and factories, and by the miles of docks crowded with shipping of all kinds, from the smallest river craft to the largest ocean vessels.

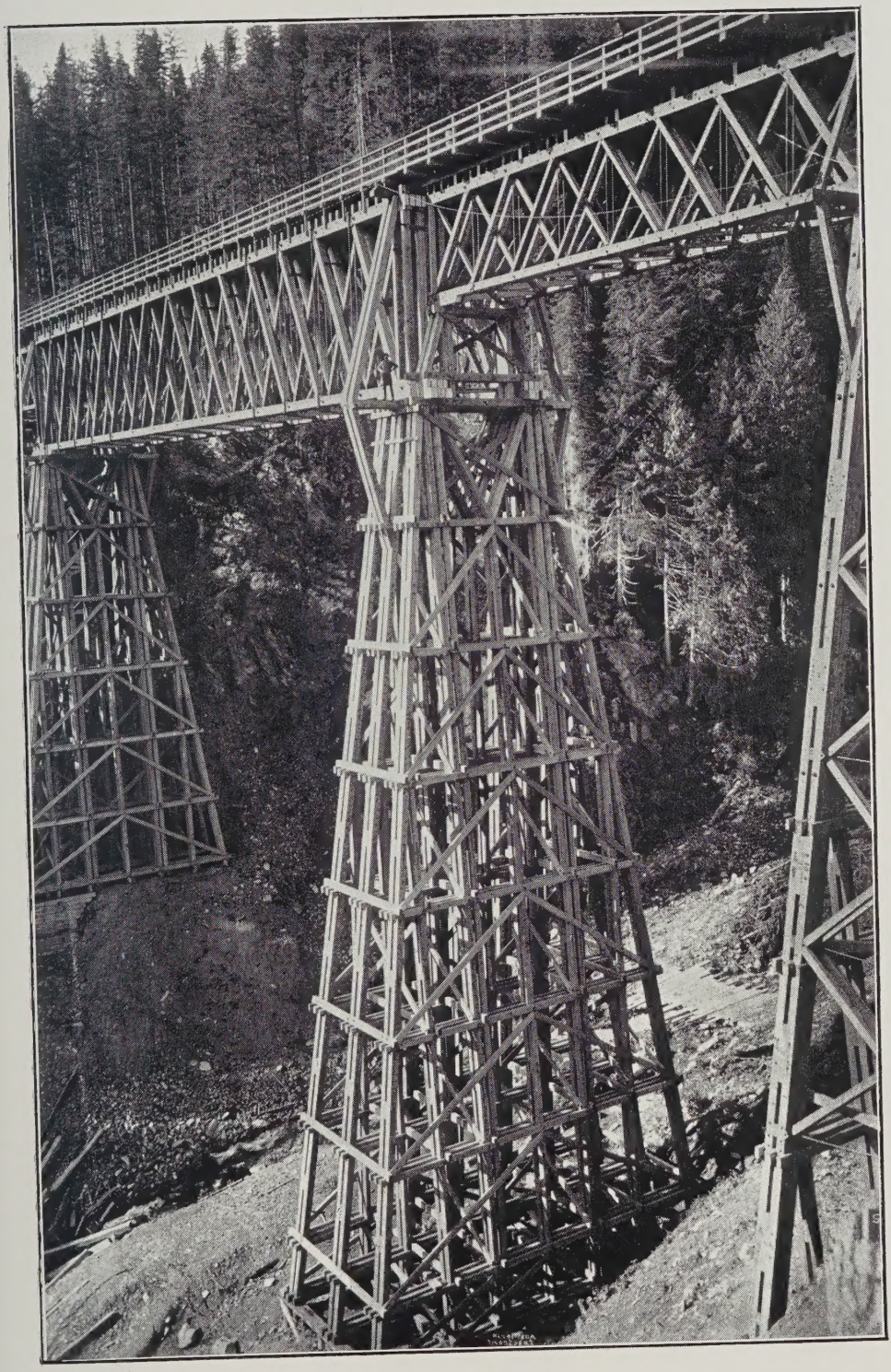
But we must not linger in Montreal or Ottawa. To see the railway at its best we should look westwards. Before the bell rings for departure we may spare a few minutes to glance at the giant locomotive, hissing gently through its safety-valve to remind us of the power stored within its painted barrel. At the front is the cow-catcher, which would make short work of the famous "coo" held up to George Stephenson as a possible cause of trouble on his first projected line. The catcher is meant for business, and out West it often finds business to do among the herds of the prairie.

Next to the engine we have an express or parcels van, then a long post-office van, in which a number of clerks busily sort letters and neatly stow the mail

sacks. After this a luggage van, full to the roof of all manner of personal property. Following it are two or three bright and cheerful colonist coaches, with seats which may be transformed into sleeping bunks at night, and with all sorts of neat contrivances for the comfort of the emigrants bound for the corn-land of Manitoba. The most striking part of the train is made up of the handsome dining and sleeping first-class saloons, built on a far more generous scale than those of the Old Country, where tunnels and bridges are numerous, and the "loading-gauge" much lower. The "sleeper" is larger and more luxurious. It has soft and rich cushions, silken curtains, thick carpets, delicate carvings, and beautiful decorations ; in fact, it reminds one of a part of an ocean liner got adrift on to wheels.

A few miles beyond Ottawa, the scene of more than one devastating fire, we quit the French country. The farms are more extensive, the houses more imposing, until the run across to Lake Superior has fairly begun. In the forest-clearings villages have sprung up here and there. Men are hard at work felling trees and making homes for themselves. They build in faith ; the railway runs within sight of their windows, ready to carry out into the wide world the products of the fields which in imagination they already see ripening to the harvest.

At intervals of a few hours the train rolls into the railway divisional stations, where the engines are cleaned, changed, and repaired, if necessary. On



A Huge Wooden Trestle Bridge at Surprise Creek, on the Canadian Pacific Railway.

The track is 360 feet high above the river bed.

[*To face p.* 72.

reaching Sudbury—half-way between Montreal and Fort William, on Lake Superior—we have our first insight into the mineral wealth of Canada. In the sidings are long strings of cars, piled high with copper and nickel ores, for transport to the sea. Close by is the richest known deposit of nickel in the world, and nickel is now a very valuable metal. Sudbury connects with the United States systems by a rail running to Sault Ste. Marie, and thus has a position ensured for it as a future town of great importance.

The trains that have passed us laden with cattle, grain, and flour remind us that Canada's chief asset is not, after all, minerals. We have only to look out of the windows and see the great forests stretching away right and left of the line to remember what wealth those serried ranks of firs represent in a world where the timber supply is rapidly decreasing. The C. P. R. aids the great waterways of Canada to transport this timber to the sea coast, whence it is shipped in vast quantities to Europe.

We are now running over one of the most difficult and costly sections of the road to the north of Lake Superior. "For many hours we look out upon the lake, its face just now still and smooth, and dotted here and there with sails, or streaked with the black smoke of a steamer. At times we are back from the lake a mile or more, and high above it; again we are running along the cliffs on the shore as low down as the engineer dared venture. Hour

after hour we glide through tunnels and deep rock-cuttings, over immense embankments, bridges, and viaducts, everywhere impressed by the extraordinary difficulties that had to be overcome by the men who built the line."

Fort William, on Thunder Bay—the lake is large enough to have bays—is the lake terminus of the western section of the railway. Here we begin to understand what the North-West is. By the lake side rise huge buildings, aggressive, unpicturesque. They are grain elevators, with a capacity of nearly two million bushels each. In the harvest season grain-laden trucks steal up behind them on the sidings day and night. Endless chains of buckets, or suction pipes, whisk the grain from the cars to the division of the elevator reserved for that particular quality of produce. The farmer is handed over the money value of the grain, and there is an end of the business as far as he is concerned. In this way enormous quantities of wheat, &c., are collected, ready for distribution at a convenient time when there is most demand and prices are good. The grain is run through shoots into cars for the railway, or into boats for the lakes. Direct water communication exists between Fort William and Montreal. A grain boat passes from Lake Superior to Lake Huron by the Sault Ste. Marie three-locked canal, from Huron into Erie by the St. Clair and Detroit rivers, and from Erie into Ontario through the Welland Canal, which turns the flank of the Niagara

Falls. The last lake of the series is connected to Montreal by five canals, all of which will float a boat drawing a maximum of 14 feet of water.

As a sign of the change that the railway has worked in the Lake Superior region, it may be mentioned that the fur-house of the old fort is now used as an engine-shed.

For the next 400 miles we are traversing historic country, through which, in 1870, Colonel (now Lord) Wolseley led his troops to quell Louis Riel's rebellion on the Red River. It is also a country of great woods, which furnish timber to the prairie region, by rail, after the trees have been sawn up in the mills deriving their motive power from the Lake-of-the-Woods. "Its waters break through a narrow rocky rim at Rat Portage and Keewatin, and fall into the Winnipeg River. Near Keewatin are the immense works of the Keewatin Power Company, creating one of the greatest water powers in the world, making of the Lake-of-the-Woods a gigantic mill-pond, with an area of 3000 square miles, and affording most convenient sites for pulp-mills, saw-mills, flouring-mills, and other establishments for supplying the needs of the great North-West, and for manufacturing its products on their way to eastern markets."

Thirty years ago a little fort, built by the Hudson Bay Company, kept solitary guard on the Red River at its junction with the Assiniboine. It had a population of 100 people. Then the railway was *talked*

of. In 1874 arose a small town of nearly 4000 inhabitants. In 1878 the railway *arrived.* To-day it is a city of 60,000 souls, with electric street trams, electric lights, parks, mills, factories, and fine public buildings. It is the locomotive centre of the western section of the C. P. R. "Situated just where the forests end and the vast prairies begin, with thousands of miles of river navigation to the north, south, and west, and with railways radiating in every direction like the spokes of a wheel, Winnipeg has become, what it must always be, the commercial focus of the Canadian North-West. Looking at the long lines of warehouses filled with goods, and the fifty miles or more of railway tracks all crowded with cars, you begin to realise the vastness of the country we are about to enter. From here the wants of the people in the West are supplied, and this way come the products of their fields, while from the far North are brought furs in great variety and number." Winnipeg is as far from what it was in the days of the first Red River Rebellion as from what it will be fifty years hence—the Chicago of Canada.

On leaving Winnipeg we enter the biggest "run" of the journey—the 1000 miles or so to the Rockies, through Manitoba and Assiniboia. Only a few years ago this trip took six weeks under favourable conditions, and the ox-trains thought they did well to accomplish it in three months. Now it occupies two days.

In his interesting book, "3800 Miles across

Canada," Mr. J. W. C. Haldane thus writes of Manitoba: "Previous to 1870 Manitoba was known only as a fur-bearing country, inhabited by Indians and half-breeds. At that time the population numbered 10,000, not more than 1000 of whom were whites, who were chiefly in the employ of the Hudson Bay Company. In 1881 the population had increased to 65,000. Owing, however, to the tremendous impetus given to the colonisation of the whole country by the opening of the Canadian Pacific Railway, the population has risen by leaps and bounds until it is now about 270,000. Further than this, it may be said that when the wonderful capabilities of the province are better known to the millions of people in the crowded portions of old countries, and in the non-productive parts of others, the increase will be much more rapid."

To provide for the influx of settlers, the Government has accurately surveyed Manitoba and the North-West Provinces, and cut them up into a gigantic chessboard of squares. Each square is six miles on the side, and is called a "township," being cut up into thirty-six smaller squares, called "sections," which are again subdivided into four squares. A road allowance, one chain wide, is provided between each section running north and south, and between every alternate section east and west. All the sections are numbered, the odd numbers belonging to the C. P. R., the even to the Government and the Hudson Bay Company. Two sections, Nos.

11 and 29, are reserved for schools in each "township." The Government lands are open for free settlements by any person who is the sole head of a family, or by any male over eighteen years of age, to the extent of 160 acres each.

Manitoba is an Indian word signifying "God's Country," and the title is indeed justified by the productive qualities of the rich, black soil, two to four feet deep, that overlies a stratum of valuable loam varying in thickness from five to sixty feet. Even the "black earth" of Central Russia and the mid-Siberian plains are not more ready to laugh with a harvest if tickled with a hoe. This fertile belt, as large as the whole of the British Isles, could grow wheat to feed the Empire; and to-day "Manitoba No. 1 Hard" is the standard of excellence by which all other wheat crops are judged. In 1903 this province yielded over 80,000,000 bushels of grain crops; and of its 25,000,000 acres of arable lands not one-half are yet occupied. Twenty years hence, when the constant influx of British, American, German, Scandinavian, and Russian settlers has filled the vacant places, and more scientific methods of farming prevail, the output will be doubled, if not trebled.

Leaving Winnipeg, we roll out into a broad plain, as level and green as a billiard table, extending north and south far beyond the horizon. To the left well-tilled farms and comfortable farmhouses succeed one another in a continuous line; to the right

countless cattle pasture on the vast meadowland. The railway is as a cue laid across the table, stretching for leagues in a perfectly straight line, over which the train runs with almost imperceptible motion. We pass through Portage la Prairie—Winnipeg on a smaller scale—whence a branch line runs hundreds of miles in a north-west direction towards Prince Albert in Saskatchewan. Then on to another thriving town and junction, Brandon, on the eastern edge of the steppes that gradually rise all the way to the Rockies. We are now on the real prairie of the buffalo and Indian, not the monotonous, uninteresting plain that you may have pictured, but a "great billowy ocean of grass and flowers, now swelling into low hills, again dropping into broad basins, with gleaming lines of trees marking the watercourses. The horizon only limits the view; and, as far as the eye can reach, the prairie is dotted with newly-made farms, with great black squares where the sod has just been turned by the plough, and with herds of cattle. The short, sweet grass, studded with brilliant flowers, covers the land as with a carpet, ever changing in colour as the flowers of the different seasons and places give to it their predominating hue. The deep, black soil of the Winnipeg valley has given place to a soil of lighter colour overlying a porous clay, less inviting to the inexperienced agriculturist, but nevertheless of the very highest value; for here is produced in the greatest perfection the most famous of all varieties of

wheat—that known as the 'Hard Fyfe of Manitoba'—and oats as well, and rye, barley, and flax, and gigantic potatoes, and almost everything that can be grown in a temperate climate. All these flourish here without appreciable drain upon the soil. Once here, the British farmer soon forgets all about fertilisers. His children may have to look to such things, but he will not."

Running through a country well stocked with game we reach Regina, the capital of the North-West Territories. It lies just 360 miles west of Winnipeg, and is an important trading point, as railways run into it from north and south. Here the North-West Mounted Police, a very fine body of men, have their headquarters. During the construction of the C. P. R. they played a notable part in maintaining law and order among the track-layers. After leaving Moose Jaw—the junction for the Minnesota and St. Paul connection—the scenery becomes absolutely treeless. In places the only vegetation is the coarse buffalo-grass, but this grass has its roots in good soil, and will presently give place to corn. Here and there an antelope, startled by the train, leaps lightly away, or a covey of prairie-chickens take wing. The line is gradually rising, a few feet a mile, from one steppe to another. It passes north of the Cypress range to Medicine Hat—named after a man who made "great medicine" for the Indians—a very important station, as here the railroad forks into two distinct routes to

Vancouver. The more northerly, through Calgary and Revelstoke, was built first, as part of the original main line; but since 1886 it has been deemed advisable to run another track through Macleod, a great ranching centre, and Kootenay, famous for the gold deposits of its neighbourhood.

Alberta, in which we now are, contains a large area of wooded land, besides the usual fertile, arable soil, which yields, in some places, 14 quarters of oats to the acre, and produces potatoes of two or three pounds weight. The latent fruitfulness of this virgin country is prodigious, and in spite of the cold winter the harvest is ready early, thanks to the heat and length of the summer days. Alberta is remarkably free from the blizzards which work such havoc further east, and as a consequence is very favourable for cattle raising. In the southern districts, where the warm Chinook blows, the winter is punctuated by spells of spring-like weather, which enables the rancher to keep his horses and cattle "out" all the year round, much to the benefit of his pocket. Many an Englishman eats beef that once roamed on the plains of Alberta.

At Calgary, a busy town of 7000 inhabitants, the Rockies come into full view, and soon the locomotive begins to taste the heavy grades, threading its way through scenery that cannot be outmatched anywhere in the world. The Canadian Government, following the example of the United States, has reserved an area of 26 by 10 miles as a

national park, near Banff, where tourists stop to make excursions into the magnificent country round about. The railway has done some very important work in thus throwing open the Switzerland of Canada to the world. Before the coming of the rails the Alps of Columbia were almost inaccessible. Now they lie exposed for any daring mountaineer to attack. Mr. Edward Whymper, the great Alpinist, has said of these mountains: "If all the mountain-climbers in the world to-day were to make a combined attempt to explore the Canadian Rockies, their task would not be completed within a century. . . . The vast ranges are appalling in their immensity and grandeur, for here are fifty or sixty Switzerlands rolled into one."

A few miles beyond Banff comes the "Great Divide," the highest point on the line, just a mile above sea-level. The railway begins to sink towards the Pacific, through the celebrated Kicking Horse Canyon, to Field, near which is the lovely Yoho Valley, containing the Takakkaw Falls, about 1200 feet in height. This region of rivers and lakes is a very paradise for the angler, and contains marvels of engineering. The canyon rapidly deepens till the mountains rise vertically on either side for thousands of feet, their tops but a stone's-throw apart. Down this vast chasm goes the railway, crossing from side to side to ledges cut out of the solid rock, and twisting and turning in every direction. With the towering cliffs almost excluding the sunlight, and

the river roaring down below, the passage of this gorge is a thing to remember.

Almost before the traveller has recovered from his astonishment, he finds fresh scenes to admire. The track crosses a broad valley and breasts a second range, the Selkirks, climbing up through dense forests of enormous trees to a level of 4500 feet. The descent is accomplished by means of a series of sixty wonderful curves or loops, and up we go again, this time over the Gold Range. A splendid plain crossed, the last mountain chain, the Cascades, is climbed. At Kamloops, a health resort for people with weak lungs, commences the marvellous Fraser Canyon, down which runs the river of that name. "The view," says a writer, "here changes from the grand to the terrible. Through this gorge, so deep and narrow in many places that the rays of the sun hardly enter it, the black and ferocious waters of the great river force their way. We are in the heart of the Cascade Range, and above the walls of the canyon we occasionally see the mountain peaks gleaming against the sky. Hundreds of feet above the river is the railway, notched into the face of the cliffs, now and then crossing the great chasm by a tall viaduct, or disappearing in a tunnel through a projecting spur of rock, but so well made and so thoroughly protected everywhere that we feel no sense of danger. For hours we are deafened by the roar of waters below, and we pray for the broad sunshine once more. The scene is fascinat-

ing in its terror, and we finally leave it gladly, yet regretfully."

Vancouver, the Pacific terminus of the railway, is a beautifully situated city of 27,000 inhabitants. Until May 1886 its site was covered with a dense forest. In the harbour ride vessels from China and Japan, Australia, New Zealand, California, and Alaska, discharging or taking in cargoes of tea, sugar, fish, fruit, and meat. In time Vancouver will be to Canada what San Francisco is to the United States.

To appreciate fully the importance of the C. P. R. there is but one thing to do—to make a journey over its 3000 miles, noting the signs both patent and latent of Canada's wealth, and the manner in which the railway has materialised it by making the huge strip of territory it traverses easily accessible to mankind. The conclusion of the whole matter has been thus tersely stated: "The completion and operation of the Canadian Pacific has revolutionised the trade of three continents, developed an unknown region, and transformed an unpeopled wilderness into a coming world's granary, given birth to prosperous cities, and towns, and villages, gridironed the different provinces of the Dominion with branch railways, and by creating an Imperial highway, brought Canada nearer to Great Britain."[1]

[1] "The Railway Year-Book."

CHAPTER V

THE UNION PACIFIC RAILWAY: THE FIRST OF THE TRANSCONTINENTALS

MUCH as life in the British Islands is bound up with the railways that cross them in all directions like the meshes of a huge net, the influence of the iron way has been even more felt on the other side of the Atlantic. For whereas in Britain the country has made the railway, in the States the railway may be said to have made the country, being the precursor of civilisation in waste and barren places, and not merely the most beneficial means of communication in districts already opened by roads.

Any literary work that deals with the expansion of the United States can no more avoid references to the rise of the great railway tracks than the traveller in the land of the Stars and Stripes can get from point to point without calling in the aid of the locomotive. In fact, so mightily has the invention of Trevethick grown and prospered under western skies, that the stories of the railroad and the American people are intertwined in a manner that is without parallel in any other country of the world. And the same enterprising spirit that has raised the United States in a comparatively short time to a foremost place,

both industrially and politically, among the nations, has also signalised them as in many ways the scene of the most marvellous advances in the science and practice of mechanical locomotion.

The writer of a series of interesting articles in the *Times*—from which the author of this book has kindly been allowed to quote—thus generally reviews the contrast between the positions of railway systems in the British Isles and the United States :—

"In Great Britain the era of railways followed the era of highways. The towns were settled, vested interests in real property were respected by the law, and land for railways in a country of such circumscribed dimensions could, in most cases, be obtained only at a very considerable cost, and, it might be, after a heavy outlay for Parliamentary and other expenses. At the outset, too, the promoters had to meet not only active opposition, but the full force of popular prejudices of the bitterest kind ; while, quite apart from this, it has always been regarded as a matter of course in Great Britain that a railway company was an organisation out of which every individual who had the chance might squeeze the uttermost farthing. Then, again, the British companies have been forced, either by law, by the requirements of the Board of Trade, or by the powers possessed by the various district authorities, to construct their lines in the most substantial manner. . . . In the United States, on the other hand, excepting only the case of New England, the railways preceded

the settlement of districts and the building up of the towns. They generally made the roads along which population was to follow. They were, in fact, the pioneers of national development." [1]

Though money was not so plentiful in the States as in England, the promoters of railroads had great advantages in the huge supply of timber available for conversion into sleepers and trestle bridges, and in the readiness that Government showed to give them land all along a projected route, and even to help them financially, by guaranteeing a part of the constructional expenses. The avenues created for the movement of population proving, in most instances, what the country wanted, the free lands of a Company soon increased in value, and their sale enabled the vendors to set their system in better order than was possible in the first instance, when economy demanded the laying of a track such as, in England, would horrify a Board of Trade Inspector.

Competition and speculation in railways were by no means unknown in the United States, and their results were sometimes as disastrous as in the British Isles. "Many (systems) got into a deplorable condition. Where little or nothing had been spent on them since their construction, they practically required to be rebuilt at the end of eight or ten years. In one instance an engineer who was inspecting a line that was being taken over by another Company kicked down with his foot a thoroughly

[1] The *Times*, January 5, 1903.

rotten piece of timber forming one of the supports of a trestle bridge over which a train had passed only a few days previously." [1]

After a period of speculation there naturally followed one of panic ; and about the time of the Civil War railways in America experienced a good "shaking up," out of which they emerged in a more stable condition, and better organised for a policy of expansion. That they should expand rapidly was felt to be a political necessity, as the war had proved that the States were really not one or two countries, but a number of countries, distinct in their populations, ambitions, and resources. For welding them together into anything like an harmonious and mutually supporting whole, one thing was particularly needful—vastly improved means of communication ; or in other words, an immense lengthening of railway mileage. The Eastern States already had a well-developed network in operation, stretching westwards as far as the Missouri and Mississippi ; and on the Pacific Coast engineers had laid many leagues of track. But between east and west lay the vast expanses of prairie and desert, crossed only by the mule caravan, or bands of hardy miners bound for the goldfields of California, and, as the home of the yet untamed, bloodthirsty Indian, a perilous land for white travellers.

It is impossible in the scope of a few pages to even refer to the hundreds of eastern systems of the

[1] The *Times*.

States. Not that they are without their romance, for here, as in other countries, their creation has been accompanied by many a thrilling adventure, and by constant fights with Nature. We must confine ourselves to a consideration of the mighty tentacles that spread from their western centres to the Rockies and the lands beyond.

A glance at the railway map of the United States will be profitable and instructive to one whose knowledge of the geography of the country is derived mainly from the dry details painfully accumulated in the school classroom. From St. Paul, on the Mississippi, the Great Northern reaches across to Seattle, on Paget Sound, Washington. One hundred and fifty miles south, on the average, runs the Northern Pacific, from the same eastern terminus, to Portland, Oregon—2056 miles; with other divisions and branches totalling over 5000 miles. South of that again, the eye follows the route of the Chicago and Milwaukee from Lake Michigan to Omaha, whence the Union Pacific carries it on to Salt Lake City, where in turn the Southern Pacific rails takes up the running to San Francisco. At this great seaport terminates also the Southern Pacific track from New Orleans, passing through Louisiana, Texas, Arizona, and California, in a mighty sweep of 3000 miles or more. In California it picks up the system known as the Atchison, Topeka, & Santa Fé Railway, which in the heart of New Mexico throws off a branch that stretches hundreds of miles south-

wards towards the mouth of the Gulf of California. Besides these main lines there are others, too many to enumerate, though scarcely less important, which form links in the chief arteries of transcontinental traffic, some of them working in open rivalry to one another.

To-day the opening of such a line is a comparatively peaceful process ; what fighting there may be is waged in Congress or the railway office. But when the surveyors and engineers of the Union Pacific first set their faces towards the prairies the railwayman carried his life in his hand, and the pick and shovel had to do their work behind the protection of the rifle and revolver. The ancestors of the Indian who now, phlegmatic and half civilised, watches the express roar past, fought hard against the men who came out into the prairies with flags and chains and levels as the precursors of the greater army following behind to lay a path for the iron feet of the horse that would outstrip the mustang in speed, the buffalo in strength. Thirsting for blood, the Sioux hung round the camps, and awaited the opportunity to add one more item to the cruel record of the quarrel between red man and white. It may be truly said that these early transcontinental railways were in parts laid in blood, and marked by the lonely graves of the victims of arrow and tomahawk.

The first line built right across the States from the Missouri to the Pacific resulted from the private

enterprise of a few small merchants of Sacramento, California. They, in 1861, organised the Central Pacific Railroad Company (now merged into the Southern Pacific) to carry the metals eastwards to the limits of California, where they should meet the platelayers working westwards from the Missouri, over the track now known as that of the Union Pacific Company. The project was formidable enough, including as it did the crossing of the Sierras at an elevation of 7000 feet or more, and a plunge into the great territory, 1400 miles long and 1300 miles wide, which as late as 1850 was still marked as "unexplored desert"; a tract so unknown to the Yankee, that in one stretch of 665 miles there lived but one white man. The cross-country route used by the traders was not established till 1860, when a coaching and pony express came into being. The coaches—often laden with gold-seekers bound for the Californian fields—required, we read, "1000 horses, 500 mules, and 700 men, of whom 150 were drivers. . . . Travellers by this overland route had not only to face blizzards on the deserts, to cut their way through snowdrifts, to cross swollen streams, and to endure the other fatigues and privations inevitable to a journey over deserts and mountains, but they had to run the risk of attacks from hostile Indians, and so frequent were these attacks that blood is said to have flowed in streams."[1]

[1] The *Times*, April 10, 1903.

The Sacramento merchants found support in the public opinion of the Eastern States, where bright dreams were being dreamed of the great possibilities for trade with China and Eastern Asia that would be opened by transcontinental rails. A strong feeling was also forming itself on a political basis, since the unsatisfactoriness of the isolation of the Pacific States became more and more apparent in the unsettled times preceding and continuing throughout the Civil War.

A Bill was passed through Congress in July 1862, assuring both the Central Pacific and Union Pacific of Government support, and a commencement was made in the same year at the Pacific end. Eastwards matters hung fire. Money was "tight," and the desert did not seem very attractive either to capital or labour. Consequently the charter, with its subsidy and land grants, fell somewhat flat, none of the railroads which, as President Lincoln imagined, would be benefited by the scheme coming forward to take a hand. They declared that they saw no prospects in a railroad across the desert. Individuals made desperate efforts to collect sufficient capital for a beginning, in the hope that when once things had been set in motion, money would come in. But to little purpose; and not till after the passing of a second Bill in 1864, which doubled the land grant and offered a subsidy of 16,000 to 48,000 dollars a mile of track, could a start be made at the Missouri end.

The Union Pacific Railway

Among the engineers of the line was one Dodge,[1] who, as early as 1853, had been over the Iowa and Nebraska country, surveying and looking about for the best route for a railway. On more occasions than one he found himself in danger of annihilation by the Indians, who then were mighty in the land. He pushed up the Platte River and across the plains as far as the Rockies, and took a liking for "South Pass" as the proper gate to a terminus on the Pacific, which he fixed at Portland, Oregon. In an interview with President Lincoln in 1863, he gave it as his opinion that the Union Pacific should at least start from Omaha, on the left bank of the Missouri opposite Council Bluffs.

Here, accordingly, in 1864 the first ground was broken for the Union Pacific Railway. At the commencement operations were much hampered by lack of transportation, as no railroad as yet reached the Missouri near Omaha, and all material had to be brought, at enormous cost, up the river from St. Louis. And even when considerable progress had been made, and people began to talk of the great future of the road, the granted lands did not sell well enough to cover current expenses, though the subsidy was paid as soon as a section had been completed. The Company was also seriously annoyed by the hostility of the Indians. These were ever with the surveyors going in advance of the construction trains. Many a promising young engineer found a

[1] Afterwards General Dodge, and a prominent railway man.

grave in the prairie. Nor did the Sioux hesitate to attack the plate-laying gangs, stealing upon them under cover of a swell in the ground, and, before help could come, massacring them to a man. It was no rare thing for a party to return at nightfall to find a bunch of scalpless corpses where in the morning they had left a busy band of toiling comrades. So serious were the losses in the ranks, that it became necessary to import military guards to watch over the navvies as they struggled with ties and rails.

Yet the "rail-head" gradually crept westwards across the prairie. In 1866, 260 miles of steel bars were spiked down to the sleepers; and by the end of the following year a locomotive could run 540 miles west of the Missouri. Nor were the Central Pacific folk idle. They had breasted the Sierras and prepared for the attack on the desert of Utah, where the Mormon stronghold of Salt Lake City alone had beaten back the desolation of that rainless country. The Government subsidy, far heavier for mountainous than level stretches, now loomed large before the eyes of both parties. Each strove for the richer share of the spoil, the Central Pacific men on their slope, and the Union Pacific on the western flank of the Rockies. In the last lap across the plains the going was furious, and feeling ran so high that even when the graders working in advance of the platelayers met, they continued their onward course, until they overlapped nearly two hundred miles. It had already been settled

by Congress, however, that where metals met metals, there a junction should be effected ; and this happened at Promontory Point, near Ogden, in April 1869. On May 10, in the presence of the rival armies of workers, and of a few outsiders who had come across the line for the purpose, four spikes, two of silver, two of gold, were driven home to complete the laying of the rails. A moment later the glad news had sped across the "whispering galleries" of the railroad, and in Chicago, New York, and Buffalo public thanksgivings proclaimed the opening of a new era in the history of the United States.

CHAPTER VI

THE HIGHROAD TO ORANGE LAND—THE ATCHISON, TOPEKA, AND SANTA FÉ RAILWAY

THREE centuries ago the Spanish friars founded a city in New Mexico near a tributary of the Rio Grande, and gave it the imposing title of La Ciudad Real de la Santa Fé de San Francisco, which being interpreted means "The True City of the Holy Faith of Saint Francis." As the place increased, words were whittled off its name, and to-day only a mere fragment, Santa Fé, survives of that sounding sentence. Many buildings and relics remain of the time when the Holy Inquisition pursued its gentle task among the natives who dwelt within sight of the Rocky Mountains, and when "the mailed warriors of Coronado told marvellous uncontradicted tales of ogres that were believed to dwell in the surrounding wilderness." The palace still stands in which the first Viceroy held his court, and you may see a hundred and one things to recall the persevering labours of the Spanish fathers among their treacherous and thankless flocks.

In 1680 the natives revolted against the Spaniards and drove them out of the territory. Twelve years later they were subjected again, and the country

grew in population and importance until, early in the nineteenth century, its trade with Missouri and the East became valuable. Its climate is cold in the higher regions, hot in the plains, and generally suited for the growing of maize, wheat, fruits, and tobacco, where water can be got in sufficient quantities for irrigation. Under the surface lie rich deposits of gold, silver, copper, iron, and salt, which every year are more extensively mined.

Caravans soon began to trail across the prairies between Kansas and Santa Fé, over the Raton Pass of the Rockies. The distance was 800 miles, and the round trip occupied three to four months.

"Merchandise to an enormous value was often carried by a single caravan. In spite of the protection of a strong military escort the trail was almost continuously sodden with human blood and marked by hundreds of rude graves dug for the mutilated victims of murderous Apaches and other tribes. Every scene recounted by romances of Indian warfare had its counterpart along the Santa Fé trail. The ambush, the surprise, the massacre, the capture, the torture, in terrifying and heart-breaking detail, have been enacted over and over."

Things were therefore lively on the caravan route during the first forty-five years of the century. In spite of the Apache the caravans pushed backwards and forwards with their precious burdens. But this method of transport became too slow and restricted for the adventurous merchants of the growing

Missouri States. Railways were ramifying rapidly, and until the locomotive careered across Kansas, New Mexico, and Arizona, they felt that the resources of these regions were being wasted.

On February 11, 1859, a Company was incorporated under a special Act of the Legislature for the construction of the Atchison & Topeka Railroad. The name of Colonel Cyrus K. Holliday stands out from among many others as that of the man who first realised the immense possibilities of a line across Kansas to New Mexico. While his fellow-promoters were wondering whether the game were worth the candle, Holliday had in imagination got the track across to Santa Fé, with branches north to Denver, eastward to San Francisco, southward to the Californian and Mexican gulfs. Such enthusiasm of course drew on it a large amount of ridicule, but the Colonel had the courage of his convictions; he merely smiled when others mocked, stuck with grim determination to his scheme, and before his death, in 1900, had the satisfaction of seeing nearly all his "dream" materialise into solid fact.

It was largely due to his influence that, in 1863, the name of the Company was extended to "The Atchison, Topeka, *and Santa Fé* Railroad." The shareholders now had a better conception of what they should aim at. In the same year Congress gave the road a lift by voting to the proprietors a grant of 10 square miles of territory for every mile of track laid through Kansas to its western boundary, on condition that

the road should be completed to the State limit within ten years, viz. by 1873.

As in the case of the Union Pacific, financiers hung back, and there was not much done except in the way of meetings and efforts at promotion, until July 1869, when the road was constructed from Topeka to Carbondale—so named after the rich coal measures discovered there — a distance of about eighteen miles. Then the faint-heart element prevailed again. Plague and drought were taking toll of the inhabitants of Kansas, few enough already, and it was seriously discussed whether the building of the railroad to the west line of the State, a distance of 300 miles, would result in sufficient immigration to prove a success. A committee of directors travelled by waggons over the contemplated line—which had already been staked out by daring surveyors along the Arkansas River to the Rockies—spying out the land to determine whether they could recommend the investment of money in the scheme. They saw nothing much except prairie grass, but where it grew corn could grow, and with true wisdom they decided that there was sufficient virgin wealth under the buffalo pasture to warrant a forward policy.

On their return home they gave the word for the advance. Only a few years remained to save the Government grant. Though hampered by the usual difficulties of moving material, they rapidly pushed the rail-head westwards over the billowy expanses of Kansas, completing the last stretches of the line at a

mileage per day that at the time broke all records and reflected great credit upon the organisation of the Company. As the platelayers advanced hunters got to work among the buffalo herds, slaughtering them in thousands for their hides. Their bones whitened the prairies, and the collection of them for reduction to manure became quite a flourishing industry. Yet even a year after the line had been completed the great beasts were numerous, and at one time the cold north winds drove them from the plains down to the river at Dodge City in such numbers that they actually impeded the passage of the trains. It is very unlikely that the future history of American railroading will ever again witness such a fine opportunity for the "cow-catcher" to act up to its name.

At the boundary line the Company paused for a breathing space, and then attacked the south-eastern corner of Colorado, bending their rails gently to the south-west, through the Raton Pass, which by a bold stroke they occupied just in time to forestall the engineers of the Denver & Rio Grande, who claimed Colorado for their own. The Santa Fé people won the race by a few hours, began shovelling earth at night while their rivals slept, and by dawn had established their rights to possession.

Clear of the Pass, the rails run almost due south along the eastern edge of the domain once owned by the American Fur Company. At the New Mexican boundary a tunnel had to be cut, at an elevation

of nearly 7600 feet, through half a mile of mountain. From the southern end the track drops by a winding pass into the land discovered by Marcos de Nizza 345 years ago, "above forests of pine and fir; through canyons where fierce rock walls yield grudging passage, and massive grey slopes bend downward from the sky; along level stretches by the side of the Great River of the North, whose turbid stream is the Nile of the New World; past picturesque desert tracts spotted with sage, and past mesas, buttes, dead volcanoes, and lava beds." In 1878 the first car entered new Mexico; in 1880 the railroad was blowing the whistle of western civilisation outside old-world Santa Fé. The same year the engineers were in Albuquerque, and fifteen months later at El Paso, Texas. By 1883 the Atlantic & Pacific Railway joined Albuquerque with the Pacific, and another through line was open from Chicago to the western ocean.

It is a wonderful line, this Atchison, Topeka, Santa Fé. To begin with, the main line doesn't run through Atchison or Topeka or the capital of New Mexico. They all lie near it, but not on it. The eastern terminus is Kansas, and the most important western depôts are Denver and Albuquerque. Secondly, it has a total mileage of 10,000 miles, sufficient to span the United States three times. Thirdly, its effect on the old buffalo haunts has been simply marvellous, while California owes more to it than can be easily put down on paper. You must

keep in mind the caravan and the whooping Indian to understand things properly. What has happened in Kansas? As soon as the line had reached but half way across, people began to find out that there was money to be made in the prairies. They came first by dozens, then by hundreds, then by thousands. The Company issued attractive literature, ran special trains for the benefit of possible settlers —in fact, left no stone unturned to sell their land; and they sold a lot of it. Of course, a proportion of the immigrants made a bad choice, sunk what money they had in a vain struggle with their waterless acres, and returned home, saddened. But the larger part stayed and added farm to farm. Among others arrived from Russia a band of Mennonites, whose imagination had been stirred by the busy land-agents of the "A. T. & S. F." Towards the end of the eighteenth century a body of these Quaker-like religionists migrated from Friesland in Germany to Russia, where for nearly a century they were allowed to rent and till land, enjoying at the same time immunity from bearing arms. But in 1871 the Government of the Czar gave notice that, after the lapse of ten more years, they would, as Russian subjects, be expected to undergo the usual period of military training. This was so abhorrent to their principles that 8000 of them decided to leave Russia for the greater liberty of the Texan plains, where men certainly carried arms—a brace of revolvers thrust into top-boots or many-coloured

sash—but did not interfere much with one another. They settled in the district round Newton, and, thanks to their German blood, proved useful citizens for their adopted country. Good judges of land, they picked out some of the best townships, and soon won fame as being among the most successful farmers in the States. When in 1881 hundreds of their countrymen hastily left Russia to escape conscription, they too came to Texas, and were helped by their forerunners with money and land to gain a livelihood.

All along the Arkansas Valley, to La Junta and beyond, the railway has brought into being a green strip of fertile land ; for the immigrant on his arrival watered the ground which now is covered with alfalfa, melons, beet—the last for the manufacture of sugar in huge quantities. A magician's wand has waved over the country : the magician came over the metals of the Atchison, Topeka, & Santa Fé.

Arizona, or at least that part of it through which the railway passes, is a succession of lofty plateaux, deep canyons, and arid plains, among which are seen large patches of forest, and tracks of green, park-like land jostling with barren wastes, under which precious metals await the pick of the miner. At Williams the main line throws off a short northerly branch, built to give travellers a chance of seeing one of the most wonderful sights in the world—the Grand Canyon of the Colorado. Standing on its rim the tourist soon forgets the trading side of the

great railway. He is in the presence of one of the most awful scenes that Nature has ever produced by the resistless action of centuries of the constant working of water. As far as the eye can reach is a chaotic underworld, as though mighty mountain-chains had been dragged up by the roots, and left only their pyramidal stumps behind. Far—a mile, perhaps—below the Colorada River is polishing the canyon sides with its foaming torrent as it has done, maybe, for millions of years. "The immediate chasm itself," writes Mr. C. A. Higgins in the "Titan of Chasms," "is only the first step of a long terrace that leads down to the innermost gorge and the river. Roll a heavy stone to the rim and let it go. It falls sheer the height of a church or an Eiffel Tower, according to the point selected for such pastime, and explodes like a bomb on a projecting ledge. If, happily, any considerable fragments remain, they bound onward like elastic balls, leaping in wild parabola from point to point, snapping trees like straws, bursting, crashing, thundering down the declivities until they make a last plunge over the brink of a void ; and then there comes languidly up the cliff sides a faint, distant roar, and your boulder that has withstood the buffets of centuries lies scattered as wide as Wycliffe's ashes, although the final fragment has lodged only a little way, so to speak, below the rim. . . .

"Only by descending into the canyon may one arrive at anything like comprehension of its pro-

portions, and the descent cannot be too urgently commended to every visitor who is sufficiently robust to bear a reasonable amount of fatigue. . . . For the first two miles it is a sort of Jacob's ladder, zig-zagging at an unrelenting pitch. At the end of two miles a comparatively gentle slope is reached, some 2500 feet below the rim, that is to say—for such figures have to be impressed objectively on the mind—five times the height of St. Peter's, the Pyramid of Cheops, or the Strasburg Cathedral. . . . Looking back from this level the huge picturesque towers that border the rim shrink to pigmies, and seem to crown a perpendicular wall, unattainably far in the sky. Yet less than one-half the descent has been made.

"Overshadowed by sandstone of chocolate hue, the way grows gloomy and foreboding, and the gorge narrows. The traveller stops a moment beneath a slanting cliff 500 feet high, where there is an Indian grave and pottery scattered about. A gigantic niche has been worn in the face of this cavernous cliff, which, in recognition of its fancied Egyptian character, was named the Temple of Seti by the painter Thomas Moran.

"A little beyond this temple it becomes necessary to abandon the animals. The river is still a mile and a half distant. The way narrows now to a mere notch, where two waggons could barely pass, and the granite begins to tower gloomily overhead. . . . Obstacles are encountered in the form of steep

imposing crags, over which the pedestrian must clamber. After these lesser difficulties come sheer descents, which at present are passed by the aid of ropes.

"The last considerable drop is a 40-foot bit by the side of a pretty cascade, where there are just enough irregularities in the wall to give toe-hold. The narrowed cleft becomes exceedingly wayward in its course, turning abruptly to right and left, and working down into twilight depth. It is very still. At every turn one looks to see the embouchure upon the river, anticipating the sudden shock of the unintercepted roar of waters. When at last this is reached, over a final downward clamber, the traveller stands upon a sandy rift confronted by nearly vertical walls many hundred feet high, at whose base a black torrent pitches in a giddying onward slide that gives him momentarily the sensation of slipping into an abyss."[1]

Such is the Grand Canyon of the Colorado, which this railway has made so accessible to the world. The Colorado is bridged in but two places — at Green River Station for the Union Pacific track, and at Needles, 400 miles lower down, where the "A. T. & S. F." passes over the Mojave Canyon on a huge cantilever bridge, the second largest of its kind in the world, into South California—the "Land of the Afternoon." This territory is crossed

[1] Since this account was written the facilities for a descent have been much improved.

from north-west to south-east by the San Bernardino Range, which as sharply differentiates the climate of the countries on its two slopes as do the Himalayas. To the north lies the howling Mojave desert, arid, rocky, inhospitable, where only the cactus, greasewood, and a few other hardy plants can grow—but a rich mineral field. On the south is one of the fairest gardens of the world, a veritable earthly paradise, where the summer sun and the moisture-laden clouds of the Pacific and the irrigation canals combine to clothe the land with flowers and fruit trees in prodigal abundance. Who has not heard of the lemons and oranges of Los Angeles and Riverside—those seedless oranges famous all the world over? The fortunes of this citrus-growing district are so much bound up with those of the railways passing through, that, as in the case of the Grand Canyon, a digression will be pardonable to glance at the history of Riverside, which has, so to speak, grown out of oranges.

Previous to 1870 the site of this town of 10,000 inhabitants was simply a grazing ground for cattle, and a poor one at that, from lack of water. Then there came a small band of enterprising men, who pitched upon the place as likely, with proper irrigation, to produce heavy crops of oranges. Not discouraged by the ridicule of older settlers in the district, they dug their irrigation canals and planted their first orange seedlings, and when these proved

a complete failure they tried growing lemons ; and, disappointed here again, they cultivated raisins, with some success. But so much money had been spent that their finances were almost exhausted. In a lucky hour one of them received from Washington a couple of orange trees imported from Brazil. He planted the trees, which soon proved that they were as well suited to Riverside as the rabbit is to Australia. They produced fruit of great size and good quality, and, moreover, without the pips which detract somewhat from the pleasure of eating the ordinary orange. "Buds were taken from the trees and grafted on the stock of the ordinary orange trees grown from seedlings. This grafting was a complete success, and soon there were a number of trees in Riverside producing the seedless oranges. Then everybody there wanted buds for grafting purposes, and the fortunate owner of the parent trees netted a good sum of money by selling the buds at so much each. They were worth all they cost, however, for the oranges they produced became the most popular and the most profitable grown in the United States, and they were the foundation of that remarkable development in orange growing to which California has since attained. To-day there are something like 20,000 acres of orange groves in and around Riverside planted mainly with navel orange trees, the whole of those trees having been produced directly or indirectly from the two referred to above. The

parents of so prodigious a family still survive, and are to be seen at the entrance to the famous Magnolia Avenue at Riverside." [1]

For many years Riverside supplied half of the total orange crop of Southern California; even now it grows one-third. Orange culture has been made a fine art. Cement-lined canals lead water through the orchards, which are irrigated at regular intervals all the year round. The farmer tends his trees with the utmost care, even lighting bonfires to warm the groves when the temperature falls to near freezing-point. During the winter months whites and Japanese pick the fruit and carry it to the packing-house, where it is cleaned, graded, enveloped in tissue-paper wrappers, and packed into cases.

Now we come back to our main theme—the railroad. Without the means of distributing quickly so perishable a commodity as fruit, the orchards of California would never have grown and prospered; and but for the immense quantities of Californian fruit that they handle, the southern railways across the continent could hardly pay their way. In 1901 from the Los Angeles district alone, 18,000 carloads (each carload 10 to 15 tons) of oranges and lemons were sent eastwards over the Santa Fé, Southern Pacific, and other systems for an average distance of 2000 miles. Add to this 325,000,000 lbs. of dried fruit; 1,400,000 boxes of apples; 80,500 tons of canned goods; and 12,000 carloads of walnuts,

[1] The *Times*, April 13, 1903.

vegetables, sugar, wine, &c., and you will begin to understand what effect these railways have upon the commissariat of the United States. It is a very common sight to see trains of forty waggons puffing across the plains and through the mountains with vegetables for the cities of the Eastern States ; while from the Los Angeles neighbourhood 200 truck-loads of oranges are despatched daily throughout the picking season. We may well doubt whether even the sanguine Colonel Holliday took the full measure of California when he fought so hard for the laying of the Santa Fé track.

CHAPTER VII

SOME FURTHER FACTS ABOUT AMERICAN RAILROADS

WHILE in the South, we may switch our attention off to the Southern Pacific, the longest of all the American systems. Its main line runs from San Francisco to Galveston and New Orleans, on the Mexican Gulf, crossing on its way the dreary deserts of Southern Arizona, New Mexico, and Texas, where a board marked "Sand," standing beside the rails, warns the driver to look out for the dune piled over the metals by the last storm. Through the plains the track was driven with more than the usual difficulty, as water had to be carried in large tanks for both men and engines over distances as great as 200 miles. If ever there was a hopeless-looking district it was that between Colton in Southern California and Del Rio, Texas; some 1200 miles in all of sand decorated by cactus. Water would work miracles here as elsewhere, but the water has not arrived yet; and the train panting into the mirage of the plain takes little notice of the little wayside station through which it rolls. It carries "California" on its head-boards one way, "Galveston" the other. These are the mainsprings of the system's life. About the former enough has already been said.

Of Galveston we heard much disastrous news in September 1900, when a huge tidal wave, driven by a furious hurricane, swept over the ill-fated port, and in a few moments annihilated 10,000 human beings. At the same time the greater part of the city was reduced to ruins, among the wreckage being the half-finished docks of the Southern Pacific. Galveston had been practically blotted out, so it seemed. But scarcely were the numerous dead decently buried when the engineer in charge of the docks took up the apparently impossible task of completing the Southern Pacific scheme, and issued orders that work would be continued. The wage money thus put into circulation helped largely to stave off local distress ; and the moral effect of this bold policy on the disheartened citizens was even more beneficial. Seeing the brave face shown by the Railway folk, the townspeople plucked up heart, and were soon busily engaged on a huge sea-wall, 17,000 feet long, and rising to a height of 16 feet above sea-level, which should protect the town from a repetition of the disaster. Behind this the level of the town itself will be raised 10 feet by pumping silt into enclosed areas and allowing the solid matter to settle. For the completion of this work the State of Texas has remitted the taxes which the inhabitants of Galveston pay to the State coffers, or rather has permitted the municipal authorities to expend the money at home.

At Galveston the Southern Pacific Directors have

already spent £600,000 on docks. They first of all reclaimed 205 acres of land from the Bay for wharves and buildings. Conspicuous among the latter is a grain elevator able to hold a million bushels of wheat and fill three vessels at once. It is built on 2500 piles, each 50 feet long, topped with a 12-foot layer of concrete. "The dock alongside is 1500 feet long and 250 feet wide, with a depth of 30 feet of water, and this depth is practically constant, there being a difference of only a single foot between high and low tide. Six vessels can be loaded in the dock at the same time, three on each side. I had the opportunity of seeing a steamer unloaded from the end of the pier, and could not but admire the dexterity with which the work was done. Between the vessel and the floor of the shed in which the freight cars were waiting, end on to the vessel, in gridiron fashion, there was a series of conveyors or moving platforms operated by electricity, seven being provided for each vessel. As soon as the freight was raised from the hold it was put on a truck, and this was wheeled a few feet until it reached the moving platform, which at once conveyed it up the incline to the floor of the shed without any effort on the part of the man in charge. The moment the truck reached the top of the conveyor (which has a length of 36 feet, and works on the endless chain principle, and can carry eight tons of freight at one time) it was wheeled off, the goods being taken at once to the particular train or car in

which they were to be loaded, according to destination. Truck succeeded truck up these moving platforms with the regularity almost of clockwork, and such was the despatch with which the whole business was conducted, and so close the contiguity of train and steamer, that I saw no reason to doubt the statement that 3500 tons of cargo will be discharged in the course of a single day and be sent off by train before nightfall. The Company's docks and sheds give employment to 900 men. Ample space is left for considerable enlargements at some future date, the construction of four or five more piers being contemplated by the Company, and, with the other improvements that are going on there, Galveston, the apparently ruined city of a few years ago, is looking forward to attaining a high rank among the shipping ports of the world."[1]

It is this immense terminal business at Galveston and San Francisco that justifies the hundreds of miles of track through the desert. Sugar arrives on the Pacific coast from the Sandwich Islands by hundreds of tons, is transferred to trucks, whirled across to Galveston, and there re-shipped for New York. The land journey is made on "specials" which stop only to change engines or take in water.

The Southern Pacific runs eastwards as far as New Orleans, at the mouth of the Mississippi, one of the greatest fruit-handling termini of the States. A bunch of bananas contains several hundreds of that

[1] The *Times*, April 13, 1904.

luscious fruit. Ships put into New Orleans laden with sufficient bunches to fill on the average forty railway waggons, which are soon speeding northwards over the Illinois Central on a 900-mile journey to Chicago, or to one of the great towns on the route. There is also nothing unusual about the daily despatch of 100 to 150 tons of cucumbers or tomatoes from the same port. Thanks to the length of their railways and the variety of climate prevailing in so vast a country, the United States have a very long fruit season. Thus, while Chicago is struggling with ice and snow, strawberries ripen in the open air in Louisiana ; and by the time that the southern season is over, northern fruits are coming southwards in a return current.

The fruit traffic, large as it is, forms, after all, but a very small part of the freight carried by the Eastern lines. One must remember the huge forests, cotton plantations, wheat-fields, ranches, beet-crops, oil-wells, sugar factories, and mines of the Southern States before attempting to frame an idea of what the coming of the railway means to Kentucky, Tennessee, and the Carolinas. As we approach Chicago the network of lines is a very maze, which can be threaded only by an expert. The writer has under his eye a series of maps showing constructed lines at the end of each decade. In 1850 almost all of the 9000 odd miles are concentrated on the Atlantic Coast. From Chicago you may indeed get across to Detroit at the south end of Lake Huron,

whence a steamboat carries you through Erie to Buffalo and its rail connection with New York. And from New York you can run southwards to Wilmington in North Carolina, 600 miles. But west of the Missouri the Iron Horse has not yet gone.

Two decades later a red streak has crossed the Continent to San Francisco; another juts through Kansas almost to the Colorado boundary. Chicago is connected with New Orleans, and the Mississippi with the Atlantic Coast by half-a-dozen tracks. While in Illinois, Ohio, New Jersey, and Massachusetts the lines cross each other as thickly as the slug-trails on a lettuce leaf.

In 1880 the Santa Fé and Southern Pacific have opened a second route to San Francisco, and the Northern Pacific is pushing across Dakota from St. Paul. New Orleans is in touch with the heart of Texas; and over the northern States the engineer has doubled the mileage.

Another decade passes, and the thick red patch of densest rails advances into Nebraska and Eastern Kansas, half-way across the States. The Southern Pacific is open, and if you like you can make a round trip from Chicago to New Orleans, from New Orleans to San Francisco; thence by a line running parallel to the coast 100 miles inland till you reach Washington, and back to Chicago over the now completed Northern Pacific or Great Northern.

The following figures will give a good idea of

Facts about American Railroads

Uncle Sam's energy as a railwayman. They denote the mileage open in the last year of each decade :—

	Miles.		Miles.
1830 . . .	23	1870 . . .	53,914
1840 . . .	2,818	1880 . . .	93,296
1850 . . .	9,021	1890 . . .	163,597
1860 . . .	30,635	1900 . . .	193,346[1]

To-day the United States contain over 200,000 miles of line, or two-fifths of the total mileage of the world ; and this property represents 2500 million pounds sterling, about one-sixth of American wealth. The *World Almanac* gives us some more interesting statistics for 1903. The United States rolling-stock comprises 41,626 locomotives, to haul 27,364 passenger-, 9726 baggage- and mail-, 1,503,949 freight-cars. In these were carried 655,130,236 passengers, and 1,192,136,510 tons of freight, which earned the Companies 1,720,814,900 dollars. Turning to the United Kingdom there were, in 1902, open for traffic 22,152 miles of track, valued at £1,216,861,421. The trains conveyed 1188 millions of passengers and 436,500,000 tons of minerals and general merchandise, earning nearly 110 millions sterling. In comparing the totals it must be remembered that in America a passenger or a ton of goods travels on the average much further than in the United Kingdom, while on the other hand a double track is the rule in the British Isles and the exception in the States. Perhaps the most striking

[1] "American Railway Transportation," by Emory R. Johnson.

difference is seen in the proportion of passenger to freight earnings. On the west of the Atlantic three-quarters of the total receipts come from freight, whereas on the east side the two main sources of income are nearly equal.

An Englishman visiting America, or an American visiting England has no difficulty in finding material for adverse criticism, or, if he be a fair-minded observer, for admiration. The features of American railroad practice that a Briton cannot but notice are the absence of platforms in the stations, the absence of bridges over roads, the primitive signalling methods, the roughness of the track in many places, and the reckless manner in which a line runs down or across the main streets of a town. On the other hand, he is struck with the size, power, and speed of American locomotives; with the generous dimensions and comfort of the passenger cars, and the great capacity of the freight trucks; with the magnificence, even luxury, of the terminal stations of large towns; with the many ingenious labour-saving devices employed in the handling of freight and rolling-stock. The American, while giving British lines full credit for the unequalled and uniform excellence of their tracks, safety, and speed, is unable to understand why so highly civilised a nation as the English is content with carriages split into many separate compartments; with the haphazard way in which the baggage is handled; with the comparatively cramped "loading-

gauge," which confines the rolling-stock to dimensions very inferior to those adopted by the railroads of the United States. Mr. Stephen Fiske, writing thirty-five years ago, had further to complain of the lack of "smoking" and "reserved-for-ladies" compartments, and of the exposure of the engine-driver to the weather of a fickle climate. Yet he is loud in his praises of "those splendid viaducts which enable the trains in England to enter the hearts of great cities, the cars passing over the roofs of the houses, train crossing over train, and passengers and freight brought to the centres of fashion or of business, and yet no lives endangered, no property destroyed, no time lost, nobody inconvenienced."[1]

That the criticisms on both sides are justifiable is proved by the fact that each nation is taking a leaf out of the other's book. American Companies are steadily improving their tracks to as near English standards as funds will permit, diverting a large part of the yearly profits—which in some countries would be fully divided among the shareholders—to the betterment of the system, so that it may earn even larger profits in the future. Heavier metals, better ballasting, the abolition of many level-crossings, the introduction of more efficient signals, steadily increase. The English director on his part advocates more powerful engines, the more general employment of corridor trains, and trucks of much greater capacity. The loading-gauge difficulty he cannot

[1] "English Photographs," by S. Fiske.

conquer, as the tunnels are there, and to enlarge them would involve enormous expense.

The differences between our and American railways are easily explained. When an English road is built its standard—the best—has already been decided by a Board of Trade, which takes good care that its rules are observed. The track must be most carefully fenced off, so that no animal may stray on the line. If a public road level-crossing is permitted, a caretaker must be there to shut the gates whenever a train is due. Designs for bridges are scrutinised; completed bridges must stand certain tests. Curves must not be of less than a certain radius. In short, a railway here comes into existence more or less on sufferance; but when made, is constructed as solidly as it possibly can be. Now take the case of the American line. As the opener-up of fresh countries for settlement it is often the first product of civilisation in those districts, and can pretty well dictate its own terms. There may be a wire or light wooden fencing flanking the metals, but generally such a precaution is considered superfluous; a cowcatcher heads the locomotive, and if any animal is foolish enough to get in the way, so much the worse for it. Similarly, if a town chooses to grow up on each side of the line, the railway does not feel bound to construct a series of bridges to pass the trains over the streets, though the streets are quite at liberty to burrow under the railway. The engine carries a large bell, which it

jangles loudly as it threads its way through the town. If a cart or human being persists in occupying the track again—so much the worse for it or him. In some States the railway is driven with tighter rein, and fences may be compulsory; but generally speaking, "taking one's chance" is the lot of anybody or anything crossing the track, and the list of killed and wounded becomes appalling to English ideas. In 1901, for instance, 4135 people other than passengers were killed and 3995 wounded. It should, however, in fairness be mentioned that only 838 people were killed at highroad crossings, the balance being mainly "trespassers" who found the track the most convenient—often the only—footway from place to place.

This apparent disregard of the public safety is, as already noticed, the result of the circumstances that attend the birth of an American road. Economy being the watchword of a struggling company, as it extends its feelers into unpopulated districts, it naturally does not spend a penny more than necessary on things outside its primary purpose—to run its rolling-stock from one point to another. Even the track itself is often at first very flimsily laid. As the traffic increases, and income too, the defects are remedied on one section at a time. Good hard ballast takes the place of mud, and the wooden shanty that originally disgraced the name of "station" gives way to bricks and mortar. The flimsy timber trestle disappears, and lo! in its stead

a light but strong steel structure, the last word in American engineering. After all, it is only a question of time when the present "half-baked" track will in most respects rival its English cousin. Nor must this sentence spell disparagement to Yankee lines, many of which even now are admirably laid, and as smooth as any in the British Isles.

With regard to the superior comfort of American trains, which is pretty generally admitted on both sides the water, what else can you expect? The average railway journey in the States is about ten times as long as in the United Kingdom. When you are taking a short trip on a penny steamer you don't expect the luxurious accommodation of an ocean liner. Similarly, on a railway run of a few miles you don't want the fine saloon that becomes almost a necessity when you are confined to the train for days together. In the British Isles a run of 1000 miles is an impossibility, and an unbroken journey of even 600 miles a rarity. So that, though our night expresses are fitted with sleeping saloons and the day expresses with corridor carriages, we do not find such luxury as prevails on the "Twentieth Century Limited" and the "Pennsylvania Special," which make the 912 mile run from New York to Chicago in twenty hours. On such trains you can command a bathroom and a barber's shop. If time hangs heavily, just step into the library car, or take a stroll into the observation car. If blessed with plenty of money, you pay something extra and hire

your own drawing-room. For the business man's convenience in this "hustling country," a typist and shorthand writer is part of the staff whose services are at the command of the passengers. While you whirl along you are kept in touch with the latest prices ruling on 'Change and transact your affairs as easily as in the office. "As for the lady passengers, who may not want either a typewriter or the closing prices, they are furnished with a ladies' maid, while their particular needs are further studied by the provision for them of electrical contrivances on which they can heat their curling-tongs. Then the electric lights are so arranged that one will be directly over the passenger's shoulder whether he is sitting in a corner seat against the window or reclining in his berth. The fares by these trains are substantially higher than by the ordinary express trains . . . and nobody pretends for one moment that there is any profit in the business. Still, it makes a good advertisement." [1]

What the American railroad manager does not know about advertising methods is scarcely worth knowing. As already mentioned, the bulk of the receipts comes from freight traffic, and it is that part of the business that a manager has chiefly in mind when he takes such trouble to make his passengers comfortable. If the trains are well fitted up people are more likely to travel through the country they serve ; if people travel, they see what oppor-

[1] The *Times*.

tunities are awaiting the settler; if they settle they bring more grist to the company's mill in the shape of extra freight. So that when several lines run across the same State you may easily imagine the rivalry existing between them. Some roads spend 30,000 to 40,000 dollars per annum on neat folding time-tables, which are placed about in the stations for the public to take. "A neat and attractive folder for general circulation is very desirable, particularly if competition is very strong. There is more virtue in a neatly made up schedule of trains than one would suppose. One in doubt is apt to reason that the road is kept up in a corresponding condition, and that the trains are made up on the same plan, and consequently would prefer to go by that route rather than by one whose trains were advertised on cheap leaflets."[1]

In England, if you are going a long journey, say from London to Aberdeen, you look up the time-table and select the route which seems superficially most convenient. Perhaps one line has a terminus half a mile nearer the hotel where you are than a couple of rivals, or one service is ten minutes quicker than another. If you have no personal knowledge of their respective merits, your choice is settled by a very small detail.

On "the other side" a big trip—New York to San Francisco—for instance, is a more serious matter, as you will be in the train a week or so,

[1] "The Railways of America," p. 305.

and therefore you want to get the most comfort for your money. You go to the nearest ticket-agent's office and discuss the whole matter with him. He takes a fatherly interest in your journey, enters fully into every detail, advises, arranges for sleeping accommodation, the collection of baggage, &c., and, though nominally an impartial critic of the various rival lines, probably does his best to get you to favour a particular route. You take it, and if dissatisfied call upon that agent next time you are his way, and tell him a few truths. So he is careful not to recommend anything nasty or likely to damage his business. So well equipped are all the lines, even to their emigrant-traffic vehicles, that you are sure to be comfortable; his duties are rather to consult your particular wishes with respect to the scenery, climate, &c., of the country through which you would prefer to pass.

Some companies print and distribute widely excellent guide books of their respective routes, which are sent to the United States consular agents throughout the world. The Denver and Rio Grande Railroad —to descend to particulars—spends £20,000 a year in advertising the attractions of the Rocky Mountains by means of pamphlets, magazines, coloured photographs, and other things that appeal to the eye or imagination.

Then there is the freight agent with his own luring net spread to catch the attention of business people. He craftily publishes articles in trade papers dealing

with an industry carried on at some point on his particular system, showing what chances await any one who will invest his money in a similar manner. This leads to correspondence and visits, and presently perhaps Mr. X. opens a paper mill at Y. on the Z. line. No stone is left unturned. The Great Northern Company send men round the rural districts of Illinois to give lectures illustrated with lantern slides and to follow the circuses, distributing printed matter among the collected crowds.

An even more practical way of advertising is thus described in the *Investor's Supplement*:—

"The Illinois Central has run a good-road train across country to New Orleans. Such a train consists mainly of platform cars, which carry road-making machines and road-makers; it travels slowly, and wherever it halts it talks of the value of good roads, explains how they are made, and adds the most convincing object-lesson by making a piece of road, which it cheerfully as well as necessarily leaves behind it." Again, "The Southern Railway Company provided a train of twelve cars, elaborately equipped with stone crushers, heavy steam-rollers, and all modern road-making machinery. This train toured the system under the auspices of the Good Roads Association. Quite lengthy stops were made at all important points, and exhibitions given of road making. . . . All this is part of a plan devised by the Southern Railway Company for the improvement of the waggon roads of the south in pursuance of

the company's policy to encourage the growth and development of all territory tributary to the system."

Railways that take all this trouble really deserve to succeed. In England, of course, such an outlay is unnecessary, but in America, a country of vast distances and largely undeveloped resources, it richly repays the enterprising company by the great increase in the freight traffic resulting from an influx of settlers. What is unoccupied prairie one year is dotted by isolated farms the next. In a decade, corn waves for miles without interruption, and towns have sprung up. The wayside station through which the trains hurried before is now an important depôt, handling millions of bushels of grain, which means profit to the Company. Or, thanks to the energy of the Company's prospectors, rich mineral deposits have been struck, the contents of which are transferred by the thousand tons from the bowels of the earth to the freight-car. This is profit too.

The power of the railway as a pioneer is seen most markedly in the rise of the Great Northern system, tapping the wheat districts of Minnesota, North Dakota, and Montana. This system is the creation of Mr. James J. Hill—a very prominent name in railroad politics. When eighteen years old he was an employé of a forwarding business between the United States and the Hudson Bay Company. Soon he set up for himself, and in his many travels became well acquainted with all the country round Lake Superior and the Red River. He saw the vast

possibilities of the North-West, and when the St. Paul and Pacific road got into financial difficulties, he formed a syndicate with certain Canadian friends —including the present Lords Strathcona and Mount-Stephen, and took over the track in 1879. He pushed out branches in all directions until, in 1890, the Company owned over 3000 miles of track. Even that was not enough. His railway must reach the Pacific, and without Government help. He went over every mile of the projected route to the sea coast at Seattle, Washington, suggesting to his engineers the best path for the rails. By 1877 the Great Northern was completed. Emigrants poured into the fertile plains it served in such numbers that to-day very little good land is left vacant, and the tide of settlers is overflowing on to the territories of Manitoba. "Jim Hill's" road is now one of the most prosperous of the Transcontinentals. It was built in hope, and has been established by success.

CHAPTER VIII

THE RAILROAD AS CONQUEROR

THE railway preaches the gospel of war as well as the gospel of peace. In Europe, England, India, and the Colonies, its message has been mainly the peaceful one of commercial expansion. In the United States the laying of the rails incidentally included a number of fights with the Indians, yet the purpose uppermost in the constructors' minds was the linking up of East and West for the sake of increased trade and political union.

The strategic line proper we shall find in Russian Asia ; where, in spite of anything said to the contrary, the railway is regarded as the most modern track for the God of War. The great Trans-Siberian Railway, its inception, construction, character, and cost, have been so often described that no detailed account is needed here. Moreover, as these words are being penned, the life and death struggle of Russian and Japanese at the eastern end of the line is making history so fast that the story of at least the Manchurian part of the kingdom may soon need to be rewritten and added to.

We will therefore turn our attention to the great stretch of intermingled sand and oasis, extending

from the Caspian on the west to the mountain ranges of Central Asia on the east. Across it flows from south-east to north-west the mighty Oxus, the world's most historic stream, to the Aral Sea, separating the southern Kara-Kum Desert from the Kizïl-Kum sands in the north.

During the second half of the nineteenth century the Russians were busy in Central Asia. At first they advanced from the north upon what is now Russian Turkestan, hurling their legions time after time against the fanatical tribes of the steppes. In 1854 they seized Tashkend, the present capital; held it for a short time; were driven out; and captured it again and for good in 1865; having in the meantime made great advances in the neighbouring countries. The Russian Colossus now had one leg planted firmly in Central Asia. Where should the other be placed? Between the Oxus and the Caspian lies Turkomania, once the free home of fierce tribes, none braver or more ready for the fight than the Tekke Turkomans of Geok Tepe, a fortified town thirty miles north of the Russian frontier. When these came into conflict with the Russians they were at first victorious, defeating General Lomatkin severely in more than one engagement. This happened in 1877.

Several years previously the Russians had felt the need of rapid communication with their Asian possessions, and when the Amu and Syr Darias, which penetrate the heart of the country, proved too

difficult for navigation by a fleet that it was originally intended to establish in the Aral Sea, the Government proposed a line from Orenburg, on what is now the main Trans-Siberian route, to Tashkend and Samarkand. M. Ferdinand de Lesseps was invited to draw up plans; and this imaginative engineer very soon had on paper a scheme for connecting Calais with Calcutta, by means of the European systems to Orenburg, thence by a Russian-built line to Samarkand, and on to India by a track that the English should construct from Samarkand to Peshawar. The Russians, on their side, were ready enough to supply their link in the chain; but the English held back, viewing a rail connection with their chief rival in the East as only less objectionable than the Channel tunnel. So the whole scheme was pigeonholed, and M. de Lesseps took himself off to the Panama Canal work in Central America.

By the Caspian, however, things could not be thus left alone. The Turkomans meant to make as good a fight of it as their Eastern brethren, if not a better. So the Russian Government in 1881 entrusted their reduction to Skobeleff, the "White General," who had won fame in the Russo-Turkish war of '78, as well as in previous campaigns against the northern Turkomans. He was given *carte blanche* as regarded the methods of conducting a campaign against the Akkal Teppe tribes.

Opposite Baku—the famous petroleum city—on the eastern coast of the Caspian Sea, is Krosnovodsk,

now a growing town. Thirty miles south-east lies Uzun-Ada, which became the base of warlike operations. Here thousands of camels and an army of 7000 men were collected, and Skobeleff advanced into the desert against his stubborn foe. With the sack of Geok Teppe, 300 miles away in the desert, and the terrible pursuit in which 20,000 of the enemy were slain by the ruthless Russians, we have not here to deal; our attention being rather directed to the railway built from the Caspian Sea to aid the transportation of men and materials to the "front."

It was determined to build with the greatest possible speed a railroad from Uzun-Ada to the oasis of Kizil Arvat, a distance of 145 miles. As in the case of the Trans-Siberian, an American came forward with an offer to lay the whole line and work it for an annual guarantee. But the Russians preferred to do their own road-making, and entrusted the direction of affairs to General Annenkoff, formerly military attaché at Paris, and, as he proved himself, a brilliant engineer. He had played a part in the movement of troops during the Turkish War, and called to the Commander-in-Chief's notice the fact that 100 miles of steel rails, bought for use in Turkey, had since then been lying idle in store. These were speedily shipped across the Caspian, together with 66 miles of narrow-gauge rails and small locomotives and waggons. Skobeleff did not mean to wait till the line was well forward, and started off with his army, promising that he

would have the Turkomans wiped out or crushed long before the first engine steamed into Kizil Arvat. As a matter of fact, he proved as good as his word, but the railway, even in its first stages, was so useful that the General became quite alive to its importance and afterwards took great interest in its extension.

Annenkoff had before him a task rendered difficult, not by any such physical obstacles as were encountered on the Baku-Batoum line across the mountains, but by the sandy and shifting nature of the country through which the rails would run, and by the almost complete absence of water along the route.

The line is of the 5-foot standard gauge of Russia, and single throughout. The rails and sleepers all came from Russia, as the authorities wished to encourage home industry as far as possible ; though for the navvy work they employed Turkomans, Bokhariots, and Persians, the last very sturdy fellows, but sad cowards. The 20,000 navvies were overlooked, helped, and instructed by a railway battalion of 1000 to 1500 men, all Russians, who supplied the skilled labour and brain power. Wages ruled very low, according to English ideas, the native workman receiving but 4d. to 8d. a day, and an engineer only £1 to £2, 10s. a week. So that on this head the Government were in a good position. And as for gradients, they very seldom troubled the engineers at all, the most severe being 1 in 150.

Before proceeding to details of construction we will cast a glance at the Transcaspian Railway of to-day. It starts at the solidly built station of Krasnovodsk, and runs twenty-five miles along the sea-shore to Uzun-Ada (Long Island), the original terminus. This stretch, and indeed the whole 706 miles to the Oxus, is through the famous Kara Kum or Black Sand Desert, "a wide and doleful plain, wholly destitute, or all but destitute, of vegetation, and sweeping with unbroken uniformity to a blurred horizon. . . . In its worst parts, and they are at first more frequent, it consists of a perfectly level expanse, plastered over with marl, which is cracked and blistered by the sun, and is covered with a thin top dressing of saline crystallisation. So hard is the surface that a camel will barely leave the impression of its footmark."[1] The desert is broken at intervals by oases of varying fertility, Akhal, Stek, Tejend, Merv, where the presence of a river or wells reclaims the surrounding country from the sandy waste. The most important stations to the Oxus are Kizil Arvat, 208 miles from Krasnovodsk; Askabad, 343 miles; Merv, 556 miles; Charjui (Oxus), 706 miles. The line crosses the river on a bridge $1\frac{3}{4}$ miles long—the longest in the world—built of wooden piles, over 3000 in number; though very shortly it will be diverted to a new iron bridge now reaching completion a short distance to the north. For the convenience of the river

[1] "Russia in Central Asia," p. 67. The Hon. G. N. Curzon.

navigation a section in the middle of the wooden bridge was constructed to open and permit the passage of boats. Shortly after it had been finished it had to be cut in two to pass a steamboat put together just below the bridge to carry a Russian general on a trip of inspection up the river. As the boat in question was meant for above-bridge traffic only, the assembling of the sections—brought from St. Petersburg—at the spot selected showed a strange want of common sense or accuracy on the part of those responsible for the blunder. The cutting of the bridge, none too solid to start with, impaired its stability so seriously that Mr. Henry Norman, M.P., thus describes his sensations[1] while passing over it. "Without exaggeration, I should not have been surprised if the whole thing had collapsed in an instant, and I was glad to see the solid ground underneath once more. The authorities," he adds, "seem to share this fear, for our speed was the slowest at which the engine could move at all."

From the Oxus to Bokhara, the capital of a semi-independent Khanate, is 72 miles, through fairly fertile country; then comes more desert, and at a point 934 miles from the Caspian the rails enter Samarkand, situated in another oasis. At Chernayevo (1057 miles) the track forks, one branch running northwards to Tashkend (1153 miles), a military centre of Central Asia; and another east-

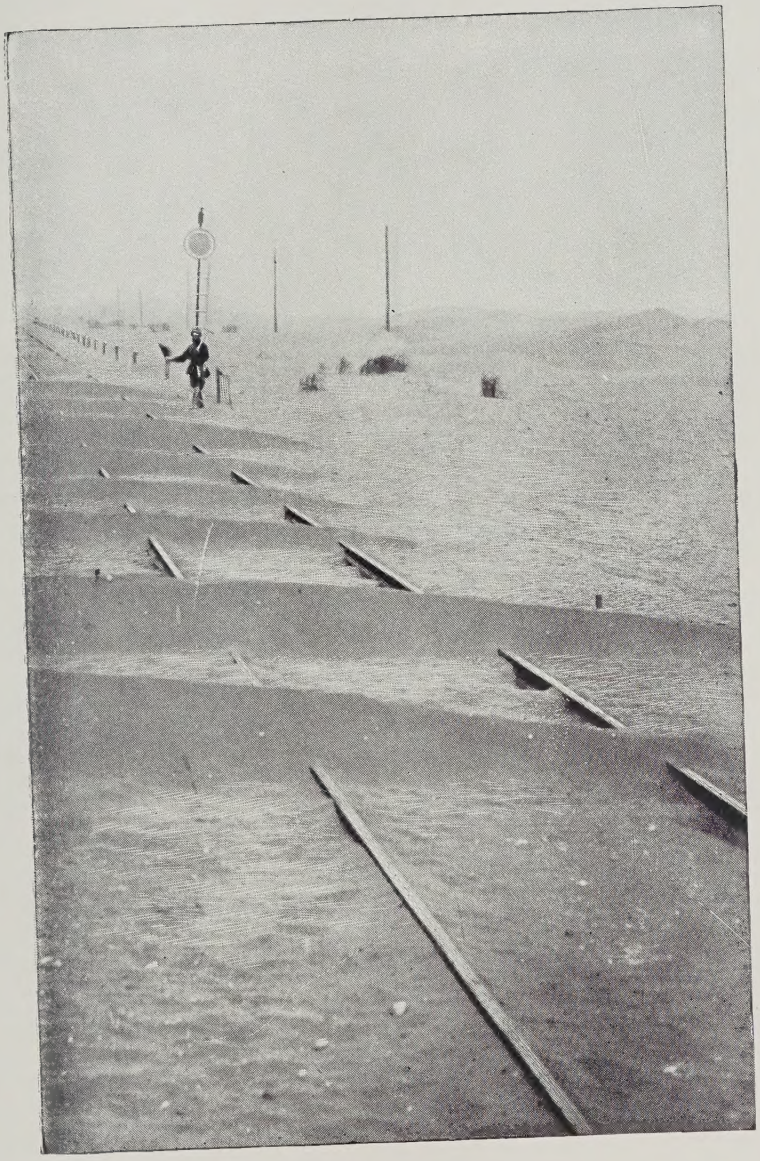
[1] "All the Russias," p. 245.

wards to Kokand, Margelan, and Andijan (1261 miles), through the well-watered cotton land of the Zarafshan Valley.

At Merv, to retrace our steps 600 miles, a branch creeps southwards for 150 miles towards the Afghan frontier, terminating at Kushinski Post. Of this section more will be said presently.

Now to return to the actual building of the line. The Russian portion of the workers lived on travelling construction trains ; made up of two-storied sleeping and dining cars, with special vehicles attached to act as travelling kitchens, smithies, and telegraph offices. The men worked in six-hour shifts, and were supplied with necessaries and material by trains that ran twice daily from the base. Natives made the embankments and cuttings ; Russians laid the sleepers and spiked down the rails. Under favourable circumstances railhead advanced at the rate of four miles a day, a speed that will compare well with that of the Canadian Pacific platelayers, working simultaneously on an even greater task in the New World. When wind and rain obstructed, the average would fall to half a mile per diem ; so that we may assume the daily mean of progress on the whole line to be in the neighbourhood of one mile and a half.

Water, or rather the lack of it, was, as already noted, a very formidable obstacle. For the first 110 miles from the Caspian there is no fresh water at all, and it became necessary to distil the Caspian



Drifting Sand across Railway Track.

Sand is the greatest enemy of the engineer in Egypt, Texas, and the Trans-Caspian provinces of Russia. In some places it has to be kept at bay by contrivances similar to those used for the checking of snowdrifts.

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brine and send the potable portion along the line in large vats, each carried on a flat truck. Artesian wells proved a failure; but in the vicinity of mountains it was easy to lead pipes down from the streams to the railway.

The workmen had two more foes to contend with, disease—taking the form of a malignant fever—and an over-abundance of sand. The last, for 200 miles at least, proved as troublesome as the snow of winter in the open steppes of the north. "The sand, of the most brilliant yellow hue, is piled in loose hillocks and mobile dunes, and is swept hither and thither by powerful winds. Is has all the appearance of a sea of troubled waves, billow succeeding billow in melancholy succession, with the sand driving like spray from their summits, and great smooth-swept troughs lying between, on which the winds leave the imprints of their figures in wavy indentations, just like an ebb-tide on the sea-shore."[1]

To combat the ever-encroaching drifts several devices were employed. Near the Caspian, sea water was poured on the sand to solidify it. Or clay was dug up in large quantities and spread abroad to form a solid blanket on the top. Where clay and water failed, the sand hills flanking the line were planted thickly with such vegetation as will grow in the desert—tamarisks, wild oats, and the deep-rooted saxaul, the last being also cut and bound up into fascines to take the place of the clay

[1] "Russia in Central Asia," p. 56.

dressing. The engineers also erected fences of wood along the summits of the dunes, to catch and arrest the driving sand in the same manner as snowdrifts are held in check by palisades and plantations on the south Russian lines. But man's utmost art cannot entirely curb nature, and were the line not constantly cleared, the metals would soon be buried deep below the minute particles borne along on every breeze.

In the matter of fuel the engineers were fortunate; for though of wood and coal there is little or none in these regions, one of earth's richest oil-fields exists in the broad neck of land between the Black and Caspian Seas. In and around Baku the country is dotted by great pyramidal structures, called derricks, beneath which the oil-finder sinks his well by means of huge drills suspended from a rope. A steam-engine raises and lowers the drill many times a minute, the rope being twisted a little every stroke. After months of labour, and the expenditure of several thousand pounds, the engineer "strikes oil," 1500 to 2000 feet below the surface. It sometimes makes a dramatic appearance, by driving the drill up the steel-lined bore like a shell from a cannon, first wrecking the derrick and then deluging the surroundings with an evil-smelling shower. A good "spouter" will yield its happy owner as much as four million gallons a day, and save him all the trouble of lifting it to the surface, for some weeks at least. Then it subsides and must be baled out by a long tube carrying a valve at its lower end.

At present the Baku district yields 52 million barrels a year; and as each barrel means 40 gallons, oil is pretty cheap in those parts. Tank steamers carry all that the Transcaspian Railway requires across to Krasnovodok, where it is stored in large tanks for transport over the line.[1] The locomotives are constructed with special oil-burning apparatus, which creates an intense heat in the fire-box, and can be more economically regulated than any coal furnace. But for this providential supply of oil the Transcaspian locomotives would be troublesome creatures to feed.

In 1881 the railway reached Kizil Arvat. There the engineers rested for four years, as their immediate purpose had been fulfilled. But in 1885 there was trouble on the Afghan frontier, and a much larger design unfolded itself, nothing less than the extension of the rails to the Ameer's boundary, and far into the heart of Turkestan, to serve military ends in the first place, with commercial traffic as a second string to the Governmental bow. The Afghans must be taught by the sight of a locomotive that Russian power meant something more than an isolated outpost or two scattered along the confines of the Czar's newly acquired territories.

So the engineers got to work again with their native diggers and delvers; while the English pushed their rails up through the Bolan Pass into

[1] Oil-fields have been discovered on the eastern shore of the Caspian, and now supply much oil for the line.

Baluchistan. On December 11th, 1885, the holy Moslem city of Askabad, whither 100,000 pilgrims flock yearly to worship at the shrine of the *iman* Reza, was reached. As a religious centre it yields place only to Mecca itself and Kerbela; and politically it has importance as the military centre of Turkomania, and the terminus of a road that passes southwards for 200 miles through Meshed into the heart of Persia.

The Russians had quietly pocketed Merv in 1884; and the way thither therefore lay open. July, 1886, saw the first train steam into the "Queen of the World," fever-stricken, but surrounded by some of the most fertile land in Asia, watered by the Murghab. Here the Russians halted a few weeks to recruit, and then drove ahead for the Oxus *en route* for Turkestan, while some of their engineers prospected the now open line running south from Merv to Kushk, only 80 miles from Herat, the so-called "Key of India." Over this branch no foreigner may travel, lest he should steal some useful secrets, in addition to the malaria that rages along the track.

In 1886 the Oxus once more gave drink to an invading host. Alexander's army had passed that way, and the barbarous Genghis Khan, and Tamerlane; and now came the host that would leave a deeper mark on the country than had any of the conquerors of old times. Even the 3000 yards of swirling water could not keep at bay the busy engineer, who beat his long piles down through the

thick mud, built trestles, and topped them with longitudinal beams, and brought rails for the "Devil's Chariot," which the Asiatic viewed at first with dismayed astonishment.

Bokhara still belonged to its Ameer and its fanatical citizens, whom the Russians did not wish to provoke by the presence of the rails. They therefore gave the city a wide berth, and joined it later to the main line by a branch.

Englishmen who know the story of Colonel Stoddart and Captain Arthur Conolly will not hear the mention of Bokhara with any feeling of pleasure. A quarter of a century ago travel in the Khanates was perilous work, which any imprudence might easily bring to a disastrous close. In 1840 these officers were sent to the Ameer by the British Government on political business. The elder man behaved indiscreetly, and both soon found themselves in a dungeon, where they lingered for three years, the prey of loathsome vermin, which, so report said, had been trained to eat human flesh. As the price of liberty they must embrace Islam. Stoddart, in despair, renounced the Christian faith ; but Conolly stood firm ; and both were led out to execution in the bazaar, Stoddart, like Cranmer before him, at the supreme moment expressing repentance for his apostasy. The only bright spot in the story is the heroism of the Rev. Joseph Wolff, a clergyman of the Church of England, who took his life in his hands and went to Bokhara to get news of his old friends.

He too was imprisoned, and would have shared their fate but for the intervention of the Shah of Persia, who demanded his release. "For five days," he afterwards wrote, "poor Colonel Williams was engaged in pulling the vermin off my body."[1] The English Government did nothing to avenge the death of their two brave servants.

Bokhara of to-day is quite a different place in its attitude towards foreigners, though below the surface Mohammedan hatred of the infidel runs deep. The Bokhariot is a keen trader, and it grieves him to see the men of Samarkand and Merv flourishing more and more every year, while his own Ameer squeezes the uttermost farthing out of his pockets. The coming of the railway has brought in fresh ideas from other lands along with the devil's chariot; the Bokhariot is beginning to wriggle under his yoke, and to wonder whether, so far as this world is concerned, an Islamite Ameer is a better person to serve than a Christian dog of a Russian. Meanwhile the "dog" is slowly but surely closing his grip on the old city, and regretting that in the first instance the line did not pass right under the city walls instead of eight miles away from its gates.

May, 1888, was a brilliant month in the history of Samarkand—the old capital of Central Asia and the Athens of the East in the brave days of Tamerlane—for it witnessed the arrival of the first train, beflagged and loaded with soldiers, that panted, amid the boom

[1] For a fuller account of this episode see "All the Russias," chap. xx.

of cannon and the crash of music, into the city that still holds the ashes of the great conqueror under the dome of the magnificent tomb erected to his memory. This important place terminated the line for some years, until the expansion of Russian military schemes carried on the metals to Tashkend, now a flourishing centre of Muscovite influence and the largest city in Asiatic Russia. The streets are wide, but muddy, and like certain Siberian towns it has excellent schools, organised on the German model, where the sons of Russian residents and of the better class natives are instructed in many practical subjects, including English.

From Tashkend a line is being built 1000 miles across barren and thinly populated country to Orenburg on the Trans-Siberian system, *viâ* Kasalinsk on the Syr Daria. It is somewhat difficult to understand why preference was not given to a route from the more southern parts of Russia, say from Saratof on the Volga, round the north of the Caspian, south of the Aral Sea, and so through Khiva to join the present line at the Oxus station. This would save over 700 miles between Moscow and Merv. Very possibly, as the country is opened up to commerce, more than one railway will cross the Kara Kum Desert, marking by a green ribbon of fertility its path through the now sterile sands.

When Tashkend is joined up to Orenburg, a traveller will be able to take a ticket direct from Calais to the very heart of Asia, right into the shadows of the great Pamirs.

At Chernayevo junction the most commercial stretch of line begins, to Andijan, the chief emporium of the cotton-growing industry of Central Asia. Cotton is the staple product of Western Turkestan. When the plantations are in full working order Russia hopes to become independent of American crops ; for in spite of the militarism underlying her actions, she keeps a keen eye open for any means of winning commercial independence. With raw cotton coming in large quantities from her own Asian territories to large mills at Moscow or Baku, she will soon enter the lists as a formidable opponent of Britain, Germany, and America in the cotton industry.

The Transcaspian Railway has had a very decided effect upon English commerce, by driving it out of Turkestan. Our trade, once flourishing, with Bokhara is practically dead and buried as a result of the heavy imports levied at the frontier on all goods coming *viâ* India or Persia. Over the latter country Russia is able to tighten her grip, thanks to the menace of an army that can speedily be collected, if needs be, at Merv and hurried southwards over the mountains into the heart of the Shah's dominions. Russia certainly regards Persia as her prey, and the British as interlopers who obstruct her way to warm water on the Persian Gulf. Her eyes are on Bender Abbas near the Straits of Bab-el-Mandeb. From that port it is proposed to run a railway due north to Kerman to join there lines passing eastwards to Seistan on the Baluchistan frontier, and westwards to Yezd,

Photo by] [*F. Moore*

A Train of Oil-tanks on the Baku-Batoum Railway.

In this manner millions of gallons of petroleum are transported from the Caspian to the Black Sea.

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Isfahan, and Tabriz, the last-named place being linked to the existing rail that skirts the Caspian on the western shore from Baku to Petrovsk, crosses north of the Caucasus to Rostov on the Sea of Azov, and at that point merges into the South Russian systems. The major part of the scheme is, of course, mere paper work, but it lies close to the heart of the Czar's strategists, as its military and commercial value would be enormous. In the first place Bender Abbas, fed by rail and converted into a naval station, would practically command the Persian Gulf like another Rock of Gibraltar—if Britain ever allowed it to be fortified. At any rate the arrival of a Russian railway on the Gulf would be a serious blow to the already diminished prestige of England in Persia. Then again, considering the line from a commercial point of view, it would open a much more expeditious route to India than is at present possible even by the "Overland" as far as Brindisi, and boat through the Suez Canal. Trade follows the path of quickest transit, and the Russians therefore assume that they would cut the ground from under the feet of many British shippers as soon as "through" trucks could be despatched from Moscow or St. Petersburg for South Persia direct.

Deep anxiety has been raised in Muscovite breasts by a rival scheme which seems to be much nearer a practical issue than their own. This is the much-talked-of Bagdad railway.

"Berlin to Bagdad" is one of those catchy phrases

which tickles German ears as effectively as "the Cape to Cairo" English.

The Armenian massacres, quite recent history, but somewhat overshadowed by more important events happening in other parts of the world, aroused the indignation of Europe a few years ago. It will be remembered that Germany refused to take a hand in coercing the Sultan to maintain order in his dominions, and to call the Mahommedan population of Asia Minor off their Christian brethren. The reason for this attitude is not hard to discover. In 1899, shortly after the outbreak of the Boer War, which kept England so busy, a concession was granted by the Sultan to a German syndicate of the right to build a railway across Asia Minor to Bagdad, whence, as a matter of course, it would follow the Tigris down to the Persian Gulf at Koweit. The Germans are good business men. They stipulated that the Turkish Government should guarantee them £1000 per mile per annum, or about a quarter of a million sterling, for the new work to be done. Germany had already built and got into good working order a line 400 miles long from the Bosphorus to Konia on the northern slope of the Taurus mountains, with a branch to Smyrna. From Konia an extension was to be made through the Taurus to Europus on the Euphrates, passing on the way old Tarsus, the birthplace of St. Paul, and Haran, the home of Abraham. Ancient Bible history and the locomotive seem as far apart as the poles, and the

idea of the region that once fed the patriarchs becoming thus modernised strikes the imagination almost like a blow. As Terah moved north from Ur of the Chaldees to Haran, so the rails will run south over almost the same track near the ruins of Nineveh to Bagdad, the scene of the delightful "Arabian Nights." A southern stretch of 40 miles brings the rails once more to the Euphrates and past the site of Babylon. How these names awake the echoes of history! And yet another 300 miles to Busra. Nor must they stop there, for the Gulf itself—the great objective—is calling, and our Teutonic cousins place their finger on Koweit as the place where a naval and coaling station shall be built, four days' steaming from Bombay!

From the Bosphorus—to be crossed by a huge bridge—to Koweit is 1800 miles, and the estimated cost of the 1400 still only on paper is put at 18,000,000 pounds sterling. This expenditure being too heavy for the shoulders of the German syndicate, they invited other nations to take shares in the concern, each contributing a proportion of the capital on the following scale:—

	Per Cent.
Germany	25
France	25
England	25
Switzerland	10
Austria	5
The Anatolian Railway (Bosphorus to Konia)	10

When the subject came up for discussion in 1903 the British Government, after a long consideration of

the pros and cons, decided that it was not sufficiently represented, as Germany could count on the Swiss, Austrian, and Anatolian votes, and accordingly refused its co-operation. The remaining parties began work in a small way, and railhead is now at Eregli, to the north of the Taurus. The crossing of this range offers considerable engineering difficulties, which will not be faced until the finance of the line stands on a firmer basis—and to effect that Great Britain may perhaps be again approached, with the chance of securing more advantageous terms.

The Russian Bear naturally has a sore head to rub when it thinks of what the completion of Bagdad railway would mean to her own scheme. Which of the European countries outside Russia will care to send goods to the Gulf *viâ* the Caucasus and North Persia in event of a more southerly and shorter route running direct from the heart of Europe to the seaboard? If the German line is ever opened we shall be able to reach India in about ten days from London, which is much quicker travelling than the Russian engineers can promise.

From speculations of future railroad extension in Armenia and Persia, we may return to the present facts and possibilities of the line already in existence from the Caspian to the Afghan frontier and the heart of Western Turkestan.

What is its strategical value for an attack upon India—the great event which Russian generals believe will come sooner or later?

The subject has been well handled by the author of "Russia in Central Asia"—now Lord Curzon of Kedleston and Viceroy of India. The book in which he expressed his opinions on this point is now fifteen years old, but it was written by a man peculiarly fitted to form an unbiassed and sound judgment, however much this may now appear discounted by the subsequent trend of events in Russian and British politics.

The strength of the British forces in India was (in 1886) 70,000 British and 148,000 native troops. Of these one-half could be distributed in a short time along the most vulnerable points of the Indian frontier to meet the advancing Russians. Skobeleff laid it down that no general should think of attacking India with less than 150,000 men, the larger part of which must be reserved for the defence of the lines of communication. We may assume, however, that the native tribes have been too thoroughly crushed to meditate an attack upon the railway, and that 90,000 are left free to fight.

Suppose that the two nations come to grips, and that the opening engagements are but drawn battles, with no advantage to either side. Reinforcements will be needed. India itself could not supply 50,000 men to fill the gaps and wastage of war ; she would therefore have to look to England for help. But it is a three weeks' journey at least from the British Isles to Bombay, even if the Suez Canal route be used—a route that could be blocked by the sinking of a single hulk in the Canal. The troopships might

find this road closed to them, and then it would be necessary to double the Cape or cross the Canadian Pacific Railway. Over either of these routes troops could not be landed in India within five or six weeks, and even after reaching a port there would still remain the long land journey to the front—a matter of several days.

Russia, on the other hand, could put troops in Afghanistan within three weeks from their mobilisation in Russia, and as many of them as the railway could transport and feed. Her reserves may be counted by hundreds where England can produce but tens, and their route is not exposed to the perils of a long sea voyage with hostile destroyers on the warpath. Lord Curzon therefore concludes that the Russians have a great advantage in so far as regards speed of transport, entirely on account of her strategic railway.

The English, fortunately, have a good ally in the mountains that rise like a wall along their frontier. True, this wall has breaches in it, but with stout hearts to hold them the Man in Possession should be able to prove that the story of Thermopylæ may be retold, with a happier ending for the smaller force. There have been many schemes for the invasion of India. In 1791 the Empress Catherine planned how an army should advance down the Syr Daria to Cabul. Nine years later Napoleon and the Emperor Paul were putting their heads together over a joint invasion by French and Russians. Napoleon's

forces were to join the Czar's in the Sea of Azov, travel by river and sea to Astrabad, and thence march overland to Herat and Kandahar. Napoleon backed out of the enterprise, but the Czar held to his purpose, and despatched General Orloff with a large force from Orenburg. The Russians had advanced 450 miles when the Czar's death terminated their march, probably fortunately for them, as they might easily have found in the desert and the untamed Turcomans as deadly foes as the French afterwards met in the snows of Russia and the fierce Cossack bands.

In 1807 Napoleon revived the old cry that, in the name of humanity, Russia and France must release India from the barbarous yoke placed on her neck by tyrannical England. Again, in 1832, 1855, 1872, and 1878 Russian strategists are at work, conciliating Persia and Afghanistan that they may serve as stepping-stones for the great advance upon India. And to-day we are aware that further plans exist, modified to suit the new possibilities opened by the railway to the quick forwarding of troops. It is no longer the fashion in England to sneer at the invasion of India as a "chimera." We know too well what a railroad means, and how tenaciously the Russians hold to a purpose. Without wishing in any way to provoke our Muscovite neighbours we strengthen our frontier forts and garrisons, improve the railways of the Punjâb, and keep a watchful eye upon the politics of the Afghan Ameer's court.

To our descendants of a few generations hence it will perhaps seem a strange thing that English rails ended for so many years at Kandahar, but a few hundred miles from other rails that would put India in direct communication with Europe. Perhaps too they will marvel at the "policy of splendid isolation" that again and again has vetoed the Channel Tunnel, not understanding the deep mistrust that nations now entertain for one another. We too, on our part, can hardly conceive that the time will not come when the strategic line of Transcaspia will be a busy route for Indian commerce and the highroad for travellers hurrying East or West. "Some day, surely," says Mr. Henry Norman, "though it may be long, long hence, and only when tens of thousands of Russian and British soldier-ghosts are wandering through the shades of Walhalla, the traveller from London will hear on this very platform (Merv) the cry, 'Change here for Calcutta!'"

CHAPTER IX

MOUNTAIN RAILWAYS

THOUGH some of the railway engineer's greatest difficulties are encountered "on the flat"—*e.g.* George Stephenson's heroic struggle with the Chat Moss—those of his works which attract public attention the most are undoubtedly performed on the slopes and among the passes of the mountain range. At the present moment there are but comparatively few important mountain chains that have not felt the feet of the iron steed as it pants and struggles slowly through the haunt of kite and eagle, and the great increase in the number of globe-trotters is responsible for a corresponding multiplication of the steel tracks laid to summits commanding some of the finest views in the world.

Mountain railways, in an engineering sense, are those with gradients exceeding 3 in 100, *i.e.* which rise vertically three feet in every hundred feet of horizontal progression. On grades of a greater steepness than 6 per cent. the mere adhesion of an engine's driving-wheels is insufficient to move more than the locomotive's own weight, and recourse must be had to the rack-rail laid between the wheel-rails, up which the engine claws its way by means of cog-

wheels engaging with the rack. When the grade exceeds 25 per cent. recourse is had to a cable, which converts the railway into what is practically an inclined lift.

In England we have, as a good example of a rack-driven railway, that which climbs to the summit of Mount Snowdon, ascending about 2000 feet in 4 miles 5 furlongs. Shortly after its opening there was a disastrous accident on this line, which for a while made tourists shy of it, but now it is much patronised as a saver of time and bodily fatigue to those who are ambitious to reach the highest point in England and Wales. Busy little locomotives of 150 h.p. push two carriages, capable of accommodating over 100 persons, up the incline in about an hour. The system of rack-rail used is named after its inventor, Mr. Abt. This rack consists of two or more parallel toothed rails laid close together, which "break joint," *i.e.* have their teeth not opposite, so that the cogs on the engine pinions keep a continual grip of the rack, with the result that the running is free from jar or vibration. The excellence of the system is proved by its adoption in nearly half of the rack railways of the world.

If you desire to make the acquaintance of a cable railway go to Lynmouth in North Devon, where you will be lifted by one to the Lynton heights above; or to the Devil's Dyke, near Brighton, where another hoists pleasure-seekers from the Weald up on to the South Downs.

Photo by] [*F. Moore*

A Cutting on the Railway over the Brünig Pass, between Lucerne and Brienz.

The Riggenbach central rack is used only on the steepest gradients.

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But outside England you will have greater opportunities, notably in Switzerland. There you may have your choice of the Pilatus, overlooking the Lake of Lucerne; or the Salève, near Geneva; or the Stanserhorn, or the Brünig, or the Gornergrat, or the Righi, or the Jungfrau.

The Pilatus—so named from the legend of Pontius Pilate's spirit being condemned to roam its heights in solitary contemplation of his sins—rises to the south-west of the beautiful Lake of Lucerne. Up this a railway was built in the years 1886–1888, on an average gradient of 1 in 2⅘ths, though in places the track rises at the rate of one foot in every two. From the lower terminus, Alpnachstaad, to the upper, Pilatus Kulm, is a distance of three miles. A writer in the *Wide World Magazine* thus describes it:—"From the lake shore upwards, the foundation of the line consists of a continuous wall of solid masonry, covered with enormous slabs of granite. The ravines and torrent-beds are spanned by arches of masonry, and the rack-rail runs midway between the two smooth rails, but at a somewhat higher level. The locomotive and the carriage, with four compartments, holding eight passengers each, form one piece of rolling-stock. The curious thing about this railway is that, instead of hauling or pulling the carriage, the engine *pushes* it up. Also the boiler is placed crossways on the engine instead of in the usual manner. The speed, both in ascending and descending, is 65 yards a minute. Thanks to the extraordinary

energy displayed by the contractors, this extremely difficult undertaking was completed in the course of two short summers—little more than 400 working days. The first stoppage on the way up is made at the Wolfert Ravine, where a halt is made for the purpose of taking in water. One's glance at this point falls almost perpendicularly down into the Bay of Alpnach. Its waters, fed by the muddy torrents descending from the mountain, are not of the intense deep blue colour of the open lake but of a yellowish-green hue. Steamers passing by beneath look no bigger than walnut-shells. An upward glance reveals the continuation of the railway line at so tremendous a height above, and on a rock of such appalling steepness, that one involuntarily asks oneself whether it is really possible for a train to reach that point, which appears beyond the power of even an eagle. Arrived at length at the summit, one gazes with astonishment and awe into the frightful abysses and precipitous valleys, and towards the beautiful country between the mountain itself and Lucerne. Beyond the town stretches the lovely hill district of Central Switzerland, with its countless villages, its blue lakes, and its rivers wandering like silver threads among the forest-crowned ridges that intersect the spacious plain."

Thus in about an hour and a half the tourist is transported from the warm lake-side up through tunnels and pine woods to the breezy Kulm. Shade of Pilate! he may well exclaim, as he contrasts the

once awful solitude with the snorting of the fussy locomotive which has added one more victory to the conquests of King Steam. We may hope that, useful as the mountain railway is, it will not banish the romance from the heights it attacks, nor cause them all to be crowned with huge, unromantic hotels, where the charges are in proportion to their elevation above sea-level. Readers of that delightful book, *Tartarin sur les Alpes*, will remember how the hero of Tarrascon, eager to gain fresh laurels as a mountaineer, made full preparations for an ascent of the Righi—on foot.

"'How long does it take to climb the Righi?' he asked of a waiter who brought him his coffee and roll in the little inn at the foot.

"'An hour, or an hour and a quarter; but hurry up, the train starts in five minutes.'

"'A train for the Righi? you're chaffing me!' he gasped; but on looking through the window he saw, sure enough, a pot-bellied locomotive, 'a monstrous insect clinging to the mountain and getting its breath to scale the giddy slopes.' For the sake of his reputation he stuck to the mountain path, and after several adventures reached the summit, where he found a large hotel, as well appointed as if it had been magically transported from the boulevards of Paris!"

Just such another hotel is found on the summit of the Stanserhorn, also near Lake Lucerne. The railway leading to it is about 2½ miles long, and famous

as containing the stiffest track gradient in the world, the maximum being 620 feet per thousand. The cars are, of course, hauled up by cables passing round a drum, to which power is communicated by a water-driven dynamo. Cog rails are here dispensed with, and the brakes act by clutching a smooth rail with a vice-like action. Another peculiarity is the method adopted for enabling one car to pass another in a siding. Each car has four wheels, two of which, on the same side, are double-flanged, the others being flangeless. On reaching a siding the car is guided by the flanged wheels to right or left as the case may be, the smooth wheels passing easily over the points. The two cars on the same division of the track have the double-flanged wheels on opposite sides, the outer rail at the crossings being the "through" rail. So that, if a car has arrived at a crossing A, and is waiting on the left side of the station on its way up, the descending train will be switched off to the right. The view from the summit rivals, if it does not surpass, that from the Pilatus Kulm, though at a lower elevation by 500 or 600 feet.

Just outside Swiss territory, in France, another electric railway climbs the Petit Salève, on a gradient of 25 per 100, to a point where the tourist can gaze far and wide over Lake Leman and the Mornen Departments. But all such tracks in Europe will soon be eclipsed by that now being pushed up the Jungfrau from Scheidegg to the summit, 14,000 feet above sea-level, through a series of long tunnels bored

in the mountain side. The view from the top is one never to be forgotten.

In the United States, as might be expected, some remarkable mountain railways are working. Pre-eminent among them is that scaling Pike's Peak, a point in the Rockies 14,147 feet above sea-level, which commands a view of 100 miles radius, of a rugged, mountainous country, containing many lakes, and the sources of four great rivers—the Platte, Arkansas, Rio Grande, and Colorado. In 1858 rich deposits of gold were found in this region, and during the next four years £6,000,000 worth of the precious metal was mined. Early explorers encountered the greatest difficulty in scaling this forbidding height, which rises far above the other crests of the neighbouring mountains. General Zebulon Montgomery Pike, the discoverer, himself failed to reach the summit of the peak that bears his name. His own opinion was that "no human being could have ascended to its pinnacle."

Yet in 1890 a full gauge (4 feet 8½ inches) was opened to the topmost crag, as the result of terrible privations and difficulties successfully faced by engineers and their assistants in the survey and construction. The line, 8⅘ miles long, is a combination of the plain adhesion and rack systems. In the words of the writer already quoted:—"Passing the Half-Way House, we go up through the narrow, rugged walls of Hell Gate, and enter Ruxton Park, where for two and a quarter miles a comparatively

level stretch is to be seen, covered by beautiful groves of pine and aspen. In the distance, the smooth, round head of Bald Mountain elevates itself. To our left is the castle-shaped Sheep Rock, and just beyond is Lion's Gulch, where we get the first grand view of the majestic and imposing proportions of historic old Pike's Peak—the Father of Manitou. Now we reach a steeper incline, and are soon at Timber Line, 11,578 feet above the sea-level. A sharp turn is made, and we have passed Windy Point, and are fast climbing into the Saddle. From this point a superb view of Manitou, the Garden of the Gods, and the plains to the east may be had, while to the left are hundreds of snow-mantled peaks, which make up the Continental Divide. Seven thousand five hundred feet more and we have reached the upper terminal, the old Government Signal Station on the long-talked-of summit of hardy old Pike's Peak." Thousands make the journey yearly, and feel as well rewarded for their pains by what they see of Earth's surface as were the miners by the treasures gained with shovel and washer.

Scarcely less interesting than the Peak rail is that which ascends Mount Lowe, in California, named after Professor T. S. C. Lowe, a gentleman who has to his credit many clever inventions. It was his great desire that an electric railway should be built over the Sierra Madre Mountains. The surveys were made in 1889, and a track soon reached

Narcissus on a Swiss Railway.

Its growth is so strong that it actually impedes traffic, as the water hyacinth blocks the channel of some American rivers.

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from Altadena to a point 1000 feet below the actual crest of the mountain. The railway falls into three main portions, the lowest and highest of which are worked by mere adhesion ; the centre, a steep incline of 62 per cent., by a cable. The first stage reaches from Altadena through the magnificent scenery of Rubio Canyon to Rubio Pavilion, 2200 feet above sea-level. Passengers then change from the electric train to the cable-way, on which run two cars, balancing one another at the ends of a steel cable tested to a strain of 100 tons. The incline, perfectly straight, is 3000 feet in length, and during the transit the passenger rises or falls 1400 feet! At the upper end of the ascent is a regular little town, comprising among its buildings a fine hotel, the peer of that of the Righi Kulm, a great observatory, and a concert hall. For the delectation of those who can tire of the glorious scenery a menagerie is open by day ; while at night the country far around is illumined by a gigantic searchlight said to give a light equal to that of three million candles! For the third stage another change is made, and an electric car takes up the work, twisting in a marvellous manner along the steep mountain sides, until the buildings on Echo Mount are far below, and the spectator catches sight of vast expanses of cultivated fields stretching away to distant hills. At a height of 5000 feet above sea-level the track terminates ; but in time it will no doubt reach right up to the mountain crest.

Among other lines that there is not space to describe here are those of the Salzburg and Schafberg in Austria; the Harz Railway, Brunswick; the Paday Railway in Sumatra; and the tramway that carries passengers up the Peak of Hong-Kong. We may expect to hear in time of the Japanese issuing cheap return tickets to the summit of Fusiyama, their sacred mountain, if they persist in "westernising" themselves; and perhaps the icy bosoms of Aconcagua and Everest will some day be open to the tourist who is bored by such trifling ascents as that of Pilatus!

In consideration of their nature, mountain railways must be very carefully built, the metals laid with the utmost accuracy, the ballast kept well drained, and the track guarded in every way from the fall of rocks and earth. The sleepers must be anchored to the ground lest they should "creep" beneath the heavy pull of the passing locomotive, and constant vigilance be exercised to maintain the brakes, on which so many lives depend, in perfect order. It redounds to the credit of those who have planned, executed, and tended the steep mountain tracks, that the serious accidents in this department of locomotion may be counted on the fingers of one hand.

Note.—Probably the most severe test to which a motor car was subjected was the ascent of the Snowdon Railway. In January 1904, Mr. Harvey Du Cros tried to reach the summit on a 15 h.-p.

Ariel car, the wheels of which ran over the sleepers and ballast. A mile from the crest his progress was barred by a snowdrift, 6 feet deep, and he had to return. On a second attempt, made in May, he made the full trip in $3\frac{3}{4}$ hours, considerable delay being caused by newly laid logs and ballast, over which the car had to be pushed, and by the overheating of the engine on account of the tremendous rate at which it had to work while progressing at a very slow speed.

An account of some Indian Mountain Railways is given in Chap. XIV.

CHAPTER X

FIGHTING THE SNOW

AFTER a heavy fall of snow the labour of clearing the doorstep and front drive, perhaps also a number of pathways about the premises, is a task to be by no means despised. When a similar operation has to be performed by the corporation of a town throughout the length and breadth of its streets, it rises to the importance of a big operation, requiring good management and organisation to carry it through.

But the fight between a city and Mother Goose's Feathers is mere pigmy warfare compared with the grim battle that many railway systems are called upon to wage with the light, swirling battalions of the winter. Fog is a bad enemy to the railwayman ; but snow even a worse. For not only does it blind the driver and obscure the signals, but also breaks down the telegraph wires and builds a continuous wall across the track, which often baffles the utmost efforts made to remove it. The result is, of course, complete derangement of the whole railway system, and incalculable inconvenience to the community it serves ; not to mention great extra expenditure and decreased dividends to the shareholders.

A Snow-Plough at Work.

The snow shot out by the fans is seen as a great sheet falling to the left of the plough. Observe the blanket of snow that has slipped over the roof of the shed and covered the summer track.

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Fighting the Snow

Those of us who can count thirty or more years to our credit will have vivid recollections of the terrible snowstorms of January 1881, certainly some of the worst on record in the British Isles, especially in the south and west of England. In the course of an address to the shareholders of the Great Western Railway in the following month the chairman said:—"We had every reason, up to the middle of January, to anticipate that we might have been able to offer the shareholders a dividend in excess of what they had previously received, but you all know that in the middle of that month a snowstorm occurred, the first we have had in the history of this railway to interfere with our traffic, and wiped off something like £56,000 of the amount available for dividend. . . . There is no doubt that the storm was much more severe on our line than on any other. Its great weight fell in the counties of Berks, Wilts, and down towards Weymouth and that district. We had to excavate 111 miles of snow, varying according to the drift from 3 feet to 10 feet in depth. We had, unfortunately, fifty-one passenger trains and thirteen goods trains buried in the snow, making a total of sixty-four, and we had blocks on one hundred and forty-one different parts of the system."

Such storms are of much more frequent occurrence in Yorkshire and Scotland, where the keeping clear of the line from snow forms a regular part of the railway officials' programme. The North-

Eastern and the Scotch Companies each keep in their sheds a dozen or more snow-ploughs. These vary in size and weight, but the North-Eastern standard machine is 11 feet 7 inches high, 8 feet 6 inches wide, and about 20 feet long. The "business" end is wedge-shaped with an under-lip projecting horizontally 6 inches above the rails. This lip undercuts the snow, which is turned to right and left by the sides, and banked up on either side of the track. The rear part of the plough contains accommodation for a number of men, picks, shovels, and provisions—as experience has proved that the plough may be inextricably fixed in a drift far from a base of supplies. On one occasion a plough, weighing 30 tons, was despatched to clear the line to Gateshead, propelled by five express locomotives. After shouldering its way through a mile and a half of snow more than four yards deep it encountered a choked-up cutting, where the engine power proved insufficient for the task, and the plough had to remain embedded for the best part of two days.

The usual method of dealing with drifts on the Great Eastern Railway is to dash at them at as high a speed as circumstances will permit, and to force the plough through by sheer momentum. If the first attack fails, the engines are reversed, the plough withdrawn and a second attack made, and so on till either the locomotive or Nature conquers. Sometimes the plough has to go out on rescue duty to where a train has been snow-bound. Then the

"going" must be careful, or else the train may be found in a manner more destructive than helpful.

When the work is too heavy for the plough, the officials have to fall back on the tedious and expensive alternative of hand labour. Hundreds of men, armed with shovels, dig a lane through the drifts as soon as the storm is over. A spadeful at a time, thousands of cubic yards are thus removed, till at last it is perhaps possible to persuade the plough to finish off the job.

So serious an obstacle is snow to traffic that both in Scotland and other countries visited by heavy falls, several methods of protection for the line are adopted. In some places, especially along the sides of cuttings, a double fence of upright sleepers is erected parallel to the track, and twenty yards or so apart, to act as a check to the drifting snow. This device acts very well until the space between the fences is filled, when the cutting, of course, has to receive its share. A more scientific method is to employ sloping fences inclined towards the track, which deflect the wind into the cuttings to keep the snow in motion. Russian engineers combat the wind-blown snow of the steppes with screens of trees planted in the most advantageous positions, and well back from the metals, so that the drift forming on the lee side may not reach the line.

If all these measures prove abortive, there is but one course left—to cover the track with a snow-shed. This is done to a limited extent in Scotland

and on a large scale in North America. The Central Pacific can boast sixty and the Canadian Pacific six miles of these structures, built of stout baulks of timber to withstand the almost incalculable pressure of the avalanche. "It took years of tireless watching and 'sleeping out' on the part of the engineers to solve the snow problem. They had to get acquainted with the country and the avalanche and learn to handle it, and at the same time to take care of what they call the 'flurry,' the local hurricane produced by the passing of a snowslide. Trees standing one hundred yards clear of the path of an avalanche have been clipped off short fifty feet above the ground. Others even further away have had their trunks packed full of fine snow, so hard that a cat could not scratch it. If a slide struck a crag and shied off, the 'flurry' kept straight ahead over the obstruction, sweeping everything before it for hundreds of yards. A big avalanche—one travelling rapidly—accompanied by a good 'flurry' is said to be about the wildest thing ever seen on the hills. To steer the avalanche away from the openings between sheds, the engineers built 'Λ' splits—triangular pens filled with stone or dirt—above the gap, which caused the slide to part and pass on either side and over the tops of the snow-sheds, which in a slide country are very substantially built."[1]

The sheds are under snow for seven months in the year. Sometimes even then solid timbers

[1] "The Story of the Railroad," by Cy. Warman.

give way beneath the strain, and the line has therefore to be patrolled night and day by watchmen living in isolated shanties far away in the mountains, who in case of a mishap give timely warning to the train about to plunge into the blackness of the wooden tunnel. These watchers have summer work to do as well ; for though in many cases there is an outside track for use in the warm months, the danger of fire then threatens the sheds and anything passing near them. A spark from a shepherd's fire, a vagrant's pipe, or an engine's funnel might seize the tinder-dry wood of the snow-shed, and in a few minutes a furious conflagration would rage, fanned by the draught blowing as if through a gigantic chimney.

So, high above the track at a point commanding the sheds for miles, is built a small hut, connected by telephone with the fire station beneath. At the first sign of smoke or flame a message is flashed to where the fire-train stands ready, with steam up to start at a moment's notice to any threatened point, and deluge the blazing timbers with water. New sheds in sections are kept on hand, so that in case of disaster fresh structures may be put up at once with little delay to the traffic.

On some parts of the Central Pacific Railway the snow-sheds are built on special rails, the sections telescoping into one another, so that in the summer they may be closed up to give the traveller a better view of the grand scenery amid which they stand.

Romance of Modern Locomotion

In February, 1904, snowstorms of unparalleled severity swept over Canada, many regions of which under ordinary circumstances have an average annual fall of ten feet. A correspondent of the *Daily Express* writes on the subject :—"Never within the memory of living Canadians have such terrible snowstorms and cold been experienced as during the last few weeks. The effect on business has been paralysing, rail and tramway companies, merchants and shopkeepers alike suffering enormous losses, while terrible stories of death and suffering from the intense frost reach here from all sides.

"The Canadian Pacific Railway has been one of the heaviest sufferers, its receipts in December being £18,000 less than for the corresponding month of 1903. In January its losses were even greater, the net earnings for the month being £111,800 less than in 1903. The railway companies are having a hard fight to keep running at all. At Neepawa, Manitoba, for instance, the snowdrifts are 20 feet deep in places. All available snow-ploughs are in use, and as passenger trains have to be run with two and often three engines very few are left for the movement of freight. The result is that in many towns it is impossible to obtain any coal or other fuel.

"Accidents are also reported owing to the freezing of points and signals. Owing to a signal refusing to work, a collision occurred at Toronto between an engine and freight train, both loco-

motives being severely damaged. Traffic along the roads has ceased even by sleigh in parts of Ontario, and a member of the Provincial Legislature had to travel 40 miles on snow-shoes a few days in order to reach a railway station."

In America the drifts are too deep and too frequently formed to be shouldered aside by the ordinary plough. So hard does the snow at the bottom of a deep cutting become from the pressure of that lying above it that it is almost as stubborn as ice; and occasions have been known on which it has flung the attacking wedge-shaped plough to one side. To-day this type has been discarded for use in the passes of Wyoming, Colorado, and British Columbia; and there reigns in its stead the "Leslie" Rotary, a pattern adopted by the United States railways in 1890, after a three-day contest held on the Alpine Pass stretch of the Union Pacific.

A rotary plough is in idea a gigantic auger. It consists of a very large boiler to supply steam to powerful engines, which rapidly revolve a series of vanes attached spokewise to a central shaft. The "business end" is protected by a square-shaped shield. Behind the vanes—some 12 feet in diameter—is a chamber into which the vanes precipitate the snow just like so much air driven by a revolving fan. From this chamber the snow is expelled to right or left of the track, as may be wished, flying through the air in a continuous shower. Two or more engines propel the plough,

which will advance through snow four feet deep at the rate of 12 miles an hour, its speed of course rapidly falling as the depth increases. Yet even in drifts that rise to the funnel tops it can move at a smart walking pace.

In passes such as the Boreas, on the Great Divide, ploughs are constantly at work, and cost the railroads hundreds of thousands of dollars yearly. During blizzards it is often necessary to precede even passenger trains with a "rotary." And when a train has stuck fast a plough is sent off to help it, accompanied by gangs of men to tread down the snow where too soft for the plough, to blast it with gunpowder where too hard, and to dig it out where too deep. Sometimes the snow solidifies to such an extent as to lift the driving wheels from the rails. Then scrapers are lowered, and the plough and locomotives move backwards and forwards till the metals have been well cleaned and the wheels can bite again.

It is bad for the ploughmen if a mass of rock has been swept on to the track by a snowslide. The rotary hurls itself into the drift and works away nobly until it reaches the rock, and then—crash! one or more of the vanes are snapped off. But the engineers will not be beaten. Despite the bitter wind and driving blizzard they fix on new blades, and soon are at the drift again, after levering the obstruction off the roadway.

It is a stern fight, this battle with the snow; but

In the Californian Snow-Sheds.

These are built of stout timbers warranted to withstand the swiftest avalanche. On the down-hill side the shed is often open; hence the snow inside on the right of the track.

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it must be waged incessantly, since the interruption of transcontinental traffic dislocates the business of the States. Railway managers do not look forward to a repetition of such a winter as troubled them in 1888 and 1889, when their utmost efforts to keep the tracks open were not always successful, and trains remained buried for days together.

To secure passengers on the C. P. R. against the pangs of hunger in case of a snow-up, every through train from Montreal to Vancouver carries an emergency supply of provisions; and in the Selkirks and Gold Ranges *caches* of food, coal, and oil are buried every ten or twelve miles as an additional precaution. In short, everything possible is done that may be of use in the yearly struggle against the snows of winter.

CHAPTER XI

HOW LIFE IS PROTECTED

I.—*The Signal-Box*

IF there are two classes of men on a railway who must implicitly trust and understand one another, they are the signalmen and the engine-drivers. The driver lets his engine fly round a blind corner or into the darkness of the night with full faith in the message just given him by the lowered arm or green light of the semaphore. The signalman, jumping from lever to lever in obedience to mysterious signals rapped out by the telegraph, takes it for granted that if he says a thing through the medium of his rods and wires the driver will act accordingly.

Two pictures. The first, a man armed with a flag who, as a queer-looking, tall-funnelled engine comes in sight, steps from his little cabin to the rail-side and holds up the flag at an angle to show that the way is clear. Or perhaps his extended arm only is used. He is a somewhat comic figure, this policeman in his beaver hat and swallow-tail coat; but then he lives in the 'thirties, when block systems and telegraphs had not been heard of. The

traffic is light, the speeds low, and his primitive signals serve their allotted purpose well enough.

Now skip for the second picture, right into the present year of grace. Imagine yourself standing in Waterloo signal-box, where over 200 bright levers, ranged side by side, resemble a gigantic keyboard. The men who play the tunes, every note of the utmost importance, wear no hats or swallow-tails ; their jackets are off, their sleeves are tucked up, every action is business-like as they improvise, or seem to improvise, strange combinations on their keyboard, bending out a lever here, another there, and a couple more maybe far down the line. Every moment an arm on the gantries over the score of tracks outside the station rises or falls, giving its unmistakable message to the keen eyes watching from some engine cab ; and, could you but note it, you would see that those pointed rails at the switches are moving a couple of inches right or left in obedience to an impulse transmitted by bars from the distant cabin.

Night and day those active men are at work, shift relieving shift. On their shoulders rests an enormous responsibility, too heavy indeed to be borne, did not mechanical invention come to the aid of human fallibility. How easy it would be for a tired signalman to pull over the wrong lever, were it as independent of its fellows as one note of a piano is of the rest ! And what a hornet's nest he would soon have about his ears—reprimand, fines,

dismissal perhaps, did but a single one of the semaphores for which he is responsible tempt a train on to disaster. Invention is the child of necessity; and as the necessities of signalling are very great, we find in the signal-box and the apparatus which it controls some most ingenious mechanism, and some very clever principles of traffic-handling which they serve.

The whole subject of signalling is to-day somewhat complex, especially on lines where trains succeed one another at very short intervals of time. When a station is situated at a point where several lines converge or cross, the problem of protecting the lives of passengers and the rolling-stock of the company becomes even more intricate. Every year new contrivances are put upon the market for rendering the solution an easier matter; and some of these we propose to treat here, after a short survey of the past history of this particular branch of railroad economy.

The art of signalling was born before the railway. A century ago there might be seen, on many hill-tops in the south of England, towers surmounted by tall posts furnished with one or more movable arms. A line of these semaphores, as they were called, extended from London to Portsmouth, every one being within sight of its two immediate neighbours. Each was operated by an attendant, whose whole duty consisted of repeating any signals that he might receive from the next post.

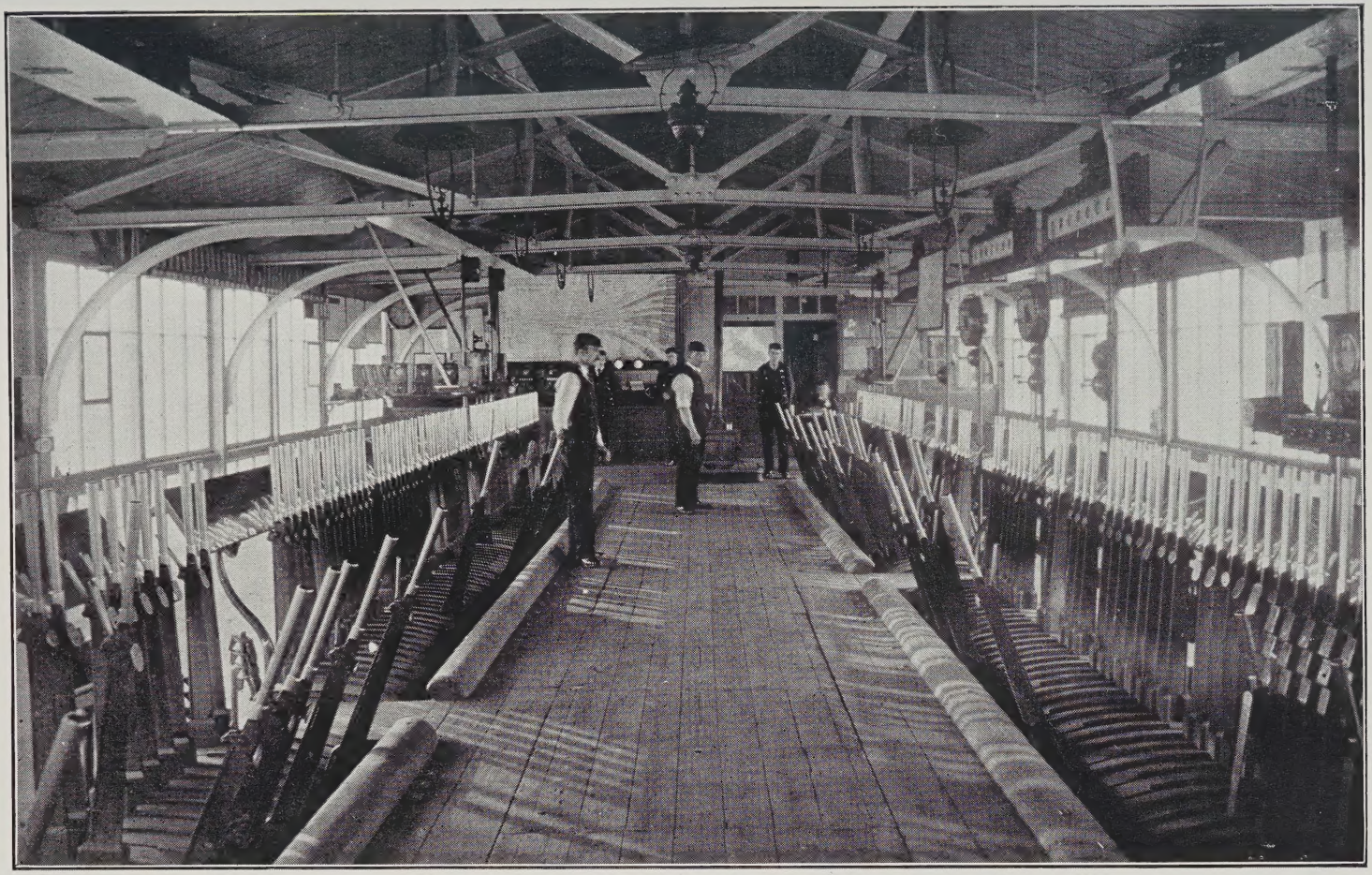

Photo by] [*F Moore*

In the Signal Box.

Waterloo Signal Box—the largest in England. By means of these hundreds of levers, 2,500 trains are worked daily in and out of the London and South-Western terminus. Notice the plan of all the points and signals on the end wall of the cabin.

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In 1842 the early railways took a hint from the Admiralty's primitive telegraph—if so it may be named. A stout post was set up beside the line, and its arm could be given one of three positions—horizontal, "danger"; vertical, "safe"; and an angle of 45° with the post, "caution." To run from one semaphore to another proving rather laborious, a certain pointsman, more inventive than energetic, conceived the idea of working the signals at a distance from his cabin by a wire and an arrangement of counterweights. This seems to us a very obvious method of saving one's legs, but like many other obvious things it took some years to discover. In 1846 the first serious concentration of signal levers at one station was made—at a London junction called the Bricklayer's Arms.

Meanwhile a great friend of the signalman had appeared—the electric telegraph. In 1839 Messrs. Cooke and Wheatstone installed their newly invented electric needle instruments over the section of Great Western between Paddington and Hanwell. It was now possible to work the "block system" on a much more elaborate scale. What is the "block system"? Take any line you like and divide it into lengths of, say, five miles each. Then instruct the signalman in the box at the commencement of each length on no account to allow a train to pass his signals until the man in the next box ahead has telegraphed that the train which he has been told to expect last has already passed *his* box. This

ensures that two trains shall never be simultaneously on the same set of metals between any two boxes. To guard against mistakes, a message must be acknowledged by the recipient; and as a further precaution matters are so arranged that no signalman can lower his signals until the man in the box ahead has electrically unlocked them.

If a railway had no branches or sidings throughout its length the regulation of traffic would be easy. But, as we all know, every station has its sidings, and many stations are junctions. And whenever a siding or junction or crossing from the "up" to the "down" metals exists, there must be points.

So the signalman has to think of his points as well as his signals. As regards the presence or absence of other trains on his own length he may work his semaphores quite correctly; but there are the points, waiting for their prey. On them he must keep a very watchful eye.

We will therefore imagine a simple junction, C. From the west a main line A C D runs eastwards through it; and a branch B C enters it from the north-west. A train is expected from D, its destination being A. When it arrives at C the signalman apparently has it in his power to send it either to A or B, according to which lever he pulls to work the points. The A-wards signal says "all clear"; how can the poor engine-driver be sure that he will not find himself flying B-wards? It is all right. He knows that the ingenious interlocking apparatus in

the cabin makes it *impossible* to open the B-branch points if the signal says "all clear" to A; and similarly, the points cannot turn a train towards A if the other signals say "all clear" to B. Furthermore, it is not in the signalman's power to clear both lines simultaneously.

Next, suppose two trains starting at the same moment from A and B. As they converge on B there is the making of a good "smash up," if both engine-drivers keep on their course. If, however, they obey the signals there can be no danger; since the signalman *must* have one signal at "stop," if the other says "go-ahead." The interlocking gear absolutely refuses to let both sets of signals say the same thing.

This gear is so important a part of the cabin, that we evidently ought to make its closer acquaintance. Without the aid of diagrams the writer is at a disadvantage in his efforts to make the reader understand how an interlocking device acts. So for the sake of clearness we will confine ourselves to a very simple combination of four levers, numbered 1, 2, 3, 4 respectively.

Number 1 works a set of points; 2, a "home" signal on the main line; 3, a "distant" signal on the main line; and 4, a "distant" signal on a branch.

On the top of each lever is a smaller lever which must be pressed back against the large lever before the latter can be moved. The small lever is

connected with a rod, in the flanks of which are a number of deep nicks. Between the large levers is a framework to act as guides for a number of bars having V-shaped ends of a size to exactly fit the nicks.

If the signalman wishes to put his main line signals at "all clear" it is no good to begin by seizing 3, since its tappet-rod (that with the nicks in it) is held fast by a bar digging it in the ribs, so to speak. The bar must first be allowed to move sideways as the tappet-rod rises, squeezing the pointed end of the bar out of its V. On examination you will find that lever 2 causes the obstruction; and that if that is pulled over 3 can also be used, and in turn number 2 is controlled by 1, which depends for movement on number 4 being in place.

So that if he wishes to allow a train to pass the points along the main line he must first of all have 4 in its normal position, "danger"; he then pulls down 1; then 2; and lastly 3. The main line driver, seeing the distant signal down, knows—

(*a*) That the home signal is down too, and the station clear;

(*b*) That the points are right for him;

(*c*) That the branch is blocked against converging trains.

This is the general principle of interlocking: signals govern signals and points, points govern points and signals; each is a master, each a slave. You will easily understand that at an important junction the

number of combinations of the scores of levers in the cabins must be enormous; and that but for this principle of interdependence mistakes would inevitably occur from time to time.

The year 1843 may be assigned as that in which the interlocking idea was first put to a practical test. To-day the principle has been so much extended that it can claim some hundreds of most ingenious inventions among the various mechanisms that assist its practice. In consequence of the large increase of traffic on many railways of late years, necessitating a greater number of tracks and considerable enlargements of stations and yards, there has arisen a distinct demand for some form of power-signalling which shall give greater ease and safety in handling heavy traffic, together with more economical working than can be obtained by the ordinary manual plant now in use.

Power-signalling, it should be explained before going further, means the employment of some natural force to move the points and semaphore arms, in obedience to an impulse given by the signalman. Thus, instead of seizing a big lever and doing *all* the work, the signalman merely "pulls the trigger" and allows compressed air, electricity or hydraulic pressure to do the hard labour. In some cases only one "power" is used, in others two are employed in conjunction. From the mechanical point of view the advantages of a "power" system are very great. It is now agreed that rods and

wires should be abolished or at least be laid underground in station yards, on account of the risk to railway officials from exposed gear, and the Board of Trade has recommended the abolition of rods and wires in busy yards in the latest Act of Parliament dealing with Railways. Besides this, train movements can be effected much more rapidly by means of a power installation, while reducing the physical labour required from the signalman to a minimum. If automatic indicators are added to show that the points and signals have done their duty, the signalman is also relieved of considerable mental strain ; so that not only can one man do the work of three, but he does it with less effort of body and mind, and consequently with less risk of being overcome by fatigue during long hours,—a by no means infrequent occurrence under the present manual system.

At Crewe all the points and semaphores of the extensive sidings are worked electrically by some 1000 little levers grouped in several cabins. When one of the levers is moved a current is passed into a powerful magnet in the case of a semaphore or "trailing-point," and through a specially designed motor if it operates a facing-point. At Bishopsgate, London, at Tyne Dock, and Bolton—among other places—compressed air and electricity are used in combination. The following description explains the system concisely :—"Near each switch is a small cylinder, containing a piston which is

attached directly to the switch movement. Compressed air admitted to one side or the other of this piston moves the switch the one way or the other. But as it would take some time for the necessary quantity of air to flow from the signal tower to a distant switch, a small reservoir is placed near the switch, and the air from this reservoir is admitted to one end or the other of the switch cylinder according to the position of a valve. For transmitting the motion from the tower to the valve compressed air might be used, but, as air is elastic, a quicker movement is got by using in the pipes some liquid which does not readily freeze, and which, being practically non-compressible, transmits an impulse given at one end almost instantly to the other. The signals are worked in essentially the same manner as the switches, except that the pneumatic valves are moved by electricity. In the front of the apparatus is seen a rank of small handles, which can be turned from side to side with as much ease as the keys of a piano can be depressed. Turning one of these handles admits compressed air to the end of a pipe containing liquid. Instantly the pressure is transmitted 500 or 1000 feet to the valve at the switch to be moved. The small levers are interlocked perfectly, and in that particular perform the duties of the ordinary machine. A model of the tracks controlled is placed before the operator, showing the switches and signals, and when a movement is made on the ground it is at once repeated back by electri-

city and duplicated on the model."[1] This beautiful system is the invention of Mr. George Westinghouse, of whom more will be said in the following chapter.

In England a low-pressure, or "all-air," system of signalling is making headway. In this method the pressure does not exceed 15 lbs. to the square inch, and for the opening of valves only half that pressure is used. One advantage of low-pressure is a comparative freedom from leakage. Generally speaking, the principle of working points and semaphores resembles that described above, except that there is no electricity employed, unless the signals are meant to be moved automatically by the trains. To shift points a cylinder is installed on the adjacent sleepers, and connected to the signal-box by four small and one large pipe, the former actuating valves and the fifth the switch cylinder. The signalman pulls a small handle towards him, and lets compressed air into one of the small pipes, which opens a valve at the switch between the large pipe and the cylinder. The piston is forced out to the right, we will assume, driving a plate containing a diagonal slot in the same direction. A pin engaging with the slot is attached to one end of the point rod, which is pulled towards the plate by the oblique thrust of the slot. As soon as the points have been shifted over and automatically locked, another slot in the plate opens a second valve, which passes compressed air back through another of the small

[1] "The Railways of America," p. 210. John Murray.

Photo by] [*F. Moore.*

The Signals outside Waterloo Station.

At night an engine-driver must be able to pick the one he wants out of the many dozen lights visible.

[*To face p.* 184.

tubes to the signal-box ; a third valve there opens, and a second piston comes into operation, driving a slotted plate, connected with the lever, to the left.

The principle embodied is one which gives absolute safety, and at the same time saves much time. The original theory of pneumatic switch and signal movements was to divide the stroke of the lever—or, more properly, handle—into two parts, so as to ensure that the points or signal is locked before the signalman can pull the lever right over and *inter*-lock it with the other levers. He moves the lever through the first part of its stroke ; this sends air to the switch, and the switch must complete its stroke and send air-pressure back to a valve attached to the lever in the cabin before the final part of the lever stroke can be effected. The lever must not finish its stroke until the switch stroke is already completed. Now, the time which the operator must wait, after making the first half stroke before he can make the second half, is short, measured in seconds, but yet is an appreciable addition to his necessary mental processes, for until he has fully performed his duty with one lever, he does not effectually turn his thought to the lever which is next to be moved. In this low-pressure machine just described the waiting is rendered unnecessary ; the air-pressure completes the lever-stroke without the man's intervention, and he is relieved of the necessity of hurrying. All this is really very wonderful.

Automatic signalling by the trains themselves is

employed on the Liverpool Overhead Railway, on part of the London Metropolitan Railway, on the new "Great Northern and City 'Tube,'" and in the 3-mile Woodhead Tunnel of the Great Central Railway.

We will consider, as an example of working, the method used in connection with low-pressure power signalling. The reader must keep clearly in mind that for the time being the signalman is nothing more than the train, and its servant, an electric battery. The rails between a point X and a point Y are all connected metallically; but insulated at X and Y from the rest of the track. The rails form part of an electric circuit, passing round a magnet attracting a bar which forms part of a second circuit working the valves of the signal-box.

As soon as a train enters the section X Y it "short-circuits" the current, which no longer reaches the magnet. The magnet releases the bar, and the second circuit being broken, a second magnet, in the signal-box, is put out of action. A valve opens and the signal at once goes to danger. As long as a train remains on X Y at danger the signal will remain too; but the moment the last pair of wheels have rolled off, the magnets work again and lower the signal to safety.

The reason for employing two electric circuits in the place of one is that a high-tension current would quickly leak from the rails to earth; so that, while a high-tension current is employed to do the hard work of the cabin, a low-tension in the rails serves

to control the high-tension. Even in wet weather the rails will hold a sufficient amount of low-tension current to work the "relay" magnet.

The striking feature of this automatic system is, that suppose a train to have broken in half or dropped a truck, even after the forward part had passed out of X Y the signals would still be set against a succeeding train, and investigation of the cause would naturally follow.

The low-pressure "power" has been fairly extensively installed on the London and South-Western Railway, at Grateley, Salisbury, Woking, Basingstoke, and Staines. Before many years have passed we shall probably see this or some other power method in general use on the big main lines.

The writer hopes that what has been here written will not be too abstruse for the average mind; and that the reader may be led to regard with increased respect the ugly wooden box past which he flashes in the express, and the man leaning out of its window as though he had nothing particular to do. His work is as hard and responsible as that of any railway servant.

A very trying time for both signalman and engine-driver is experienced during a fog, when the one is unable to see what is going on on the line, and the other what the semaphores or lights are saying. Under such circumstances the ears have to come to the rescue of the eyes. Men, usually platelayers, are stationed at the distant signals with coloured

lamps and detonators, wherewith to inform the driver of a passing train about the position of the semaphore arm. A detonator is a circular, flat metal case about two inches in diameter and containing some small percussion caps and a few grains of gunpowder. It is attached to the top of the rail by a couple of lead clips; and explodes when a wheel passes over it. The "fogger's" duty is to keep a couple of these detonators on the line while the signal is at "danger," and to take them off as soon as "all clear" is announced from the box. He also shows his lamp, so that the driver may know where he is. Even for "fogging" mechanical devices have been invented to replace human agency. One of these, called a "torpedo machine," is used on the Manhattan Elevated Railway, New York. It has a magazine of five torpedoes; and is connected to the signal levers in such a way that, on the signals being set to danger, a torpedo is placed in a position to be exploded by the first passing wheel. On the signal being returned to "clear," the torpedo, if unused, is replaced in the magazine; but if used, the next torpedo of the series takes its place. Though detonators cost but a few pence a dozen, so many have to be used in a prolonged fog that a single company sometimes expends three or four thousand pounds annually on them in addition to several more thousands required to pay for the labour of laying them in position. In course of time the

detonator will no doubt be replaced by mechanical methods of direct communication between signalman and driver. Already ingenious brains have devised apparatus which, by means of an inclined plane raised or lowered simultaneously with the semaphore arms, rings a bell in the driver's cabin, or admits steam to the whistle. The objection to these devices is that, though they can signal danger, they do not give positive information that the line is clear, and the driver can therefore pass the signal without being certain of his whereabouts.

CHAPTER XII

HOW LIFE IS PROTECTED (*Continued*)

II.—*Brakes*

As you fly along through the country, and watch the hedges spin past you like the spokes of a revolving wheel, you would have little peace of mind if you did not place implicit trust in the engine-driver. You take it for granted that he will see any warning signal, and in case of emergency will clap on the brakes. You also assume that, when he moves the little lever in the cab controlling the brakes, the latter will promptly work, clutching the wheels with a vice-like grasp, and speedily checking their onward motion. So seldom does an engine-driver overrun his signals, and so rare are the occasions on which the brake mechanism is found wanting, that the possibility of either being faulty does not enter into your calculations, and you are able to read your novel without any misgivings as to a safe arrival at the journey's end.

Not so very many years ago it was much easier for a driver to see danger ahead than to diminish the speed of his train. He had a very powerful brake on the engine, worked by a worm gear ; and the

guard had another in his van. But, even when both were hard on, a heavy express could not be arrested in less than three quarters of a mile.

As traffic increased and speed improved it became more and more necessary for the driver to have his train in good control. To effect this each pair of wheels ought to be braked, and all the brakes operated simultaneously.

The first continuous brake was worked by chains. The guard wound up one end of a main chain running along under all the carriages, and connected by short auxiliary chains with the mechanism braking the wheels. The defects of the contrivance are obvious enough. In the first place, there was the great difficulty of distributing the pull equally over all the branch chains, since one, by being a trifle shorter than the rest, might take all the pull ; and, in the second place, there was the danger of the main chain snapping at a critical moment.

So the chain was presently superseded by a flexible pipe which conducted steam to cylinders placed under the carriages. The steam drove out the pistons and, through the medium of levers, applied the brakes. It was soon discovered that steam, on account of its rapid condensation, could not be fed to a large number of vehicles without losing much of its effectiveness. Water pumped under high pressure was suggested as a substitute ; but water also was discarded, since in cold weather it froze in the pipes.

Engineers finally fixed upon air pressure as the most suitable agency ; and to-day some form of air-brake is fitted to almost every passenger train in the world.

The air-brake has developed on two separate lines. There is the compressed air system, and the exhausted air system. The former explains itself ; air is compressed by steam pumps into reservoirs from which it is admitted to the brake gear by the movement of a lever in the driver's cab. The vacuum brake, on the other hand, depends for its power on atmospheric pressure exerted on a piston from the other side of which air has been mechanically withdrawn.

We will briefly consider the two types in their main details.

Mr. George Westinghouse, a prominent American engineer, first produced a high-pressure air brake. His original design included an air-pump and a reservoir on the locomotive, and a cylinder under each car ; the whole series being connected by a train pipe. To apply the brakes the driver had only to open a valve, and send the air down the pipe in quantities proportionate to the needs of the case. The air entered the cylinders, drove out the piston rods, and so worked the brake levers. To release the brake the first valve was shut and another opened, allowing the air in the pipes and cylinders to escape into the atmosphere. The brakes then fell off of their own weight.

Though a great improvement on the chain and steam systems, Mr. Westinghouse's patents left much to be desired. For one thing, the air could not be sent quickly enough down a long train to apply all the brakes at the same moment; and there was a danger of the rear vehicles overrunning those in front. Also, if a car broke loose the severance of the air-pipe threw the whole braking apparatus out of gear.

To overcome these objections the inventor, after much hard thinking and experiment, patented, in 1872, the now famous automatic air-brake that bears his name.

Each car was now furnished with its own separate air reservoir, fed by the train-pipe, until a certain pressure was reached, when the pump was automatically stopped. The air does not flow "straight" from the pipe to the brake cylinders; it must first enter the reservoir. How then can the driver control the connection between the cylinder and the reservoir? By means of the "triple valve," which a very competent judge has pronounced to be one of the cleverest devices that ever originated in a human brain.

The valve is situated between the cylinder and the reservoir that feeds it; and it has four ports, leading respectively to the cylinder, the train-pipe, the reservoir, and the outer air. We will suppose that a train is being run out of a shed for a journey. The reservoirs are all empty, so the air-pump is set

to work, and the air, passing along the pipe, encounters the series of triple valves. The fact of there being no pressure in the reservoirs has so affected the valves that they put the reservoirs in communication with the train-pipes. In due course the reservoirs are filled. Now, if the driver stops pumping and opens a valve in the train-pipe, you would expect all the compressed air to escape again. But it doesn't; that is just where Mr. Westinghouse's genius comes in. The decrease of pressure in the train-pipe causes the triple-valve to partly revolve, connect up the reservoir with its cylinder, and apply the brakes. They will remain on until the pressures of train-pipe and reservoir are again equalised, when back goes the triple-valve to its former position, cutting off a further supply of air to the cylinders, and allowing that already there to escape. It is evident from this short statement of principles that, in case of a rupture of the couplings, the brakes would at once be applied automatically.

The invention of this brake cost Mr. Westinghouse so much money that he had not sufficient capital to put it on the market. He found, however, a gentleman who was ready to give him financial support, and also the opportunity of fitting his apparatus to a train. The brake had been so thoroughly thought out that it was a success from the start, and speedily adopted by many companies on their passenger rolling-stock. A train could now

be stopped in one-fifth of the time previously required with the hand-brake.

Though the Westinghouse brake served very well for passenger traffic, it was not equally successful on very long freight trains of forty or fifty cars. In 1886 and 1887 exhaustive trials of rival devices were held by the Master Car Builders' Association at Burlington. The perfect brake was required to check a very long train of loosely-coupled cars without allowing the rear cars to run into those already slowing in front. Trains of fifty cars were entered by the different patentees, and after the first year's trials it was found that, though the forward part of a train moving at twenty miles an hour could be brought to rest in fifteen seconds, the brakes at the tail had only *begun* to operate at the end of eighteen seconds, with disastrous results to the cars and their occupants. In the following year electricity was employed to work the air-valves, and by that means the brakes could be applied simultaneously throughout a train of any length. The Westinghouse brake appeared doomed for freight work, but its inventor set himself to work on an improved triple-valve, which applied the brakes throughout a fifty-car train in two seconds. To appreciate this it should be understood that such a train is nearly a third of a mile long! Mr. Westinghouse at once toured the various railway systems with a sample train, and gave exhibitions of the power of the brakes. The following figures, taken from "The

Railways of America," show the distances run in feet from the instant of applying the brakes till the train was brought to rest:—

	Feet.
Hand-brakes, 50 cars, 20 miles an hour . . .	794
Air-brakes, „ „ „ . . .	166
Air-brakes, „ 40 miles an hour . . .	581
Air-brakes, 20 cars, 20 miles an hour . . .	99

As a result of these trials the freight trains of America are in many cases being fitted with continuous brakes. In the States that picturesque figure, the brakesman, who dances along the top of the freight cars to screw down the brakes on the dangerous grades, will soon find his occupation largely gone. No doubt there is plenty more work for him to do in other branches of the service, and he may not entirely regret parting from his old business; for though in the summer the car-tops prove pleasant enough, they are the scene of great hardship when a snow blizzard is raging, and the brakesman is in peril of his life as he steps from one car to another with little but ice to tread upon. And since circumstances often compel him to almost run from one brake wheel to another, his position is then by no means an enviable one.

In England the vacuum brake is more largely used than the Westinghouse. The original pattern of vacuum apparatus, like the earlier type of the Westinghouse, was not automatic, being worked "straight," as engineers say, from the locomotive. On the

latter was a steam air-ejector, which quickly exhausted a large cylindrical chamber under the footplate connected with cylinders or vacuum vessels under the carriages. One end of each vacuum vessel was closed with a very stout rubber diaphragm, carrying a plate to which the braking levers were attached. When the driver wished to stop the train he turned on a tap which put the train-pipe in communication with the exhausted chamber under the engine, and, the vacuum vessels becoming partially exhausted, their diaphragms were driven in by atmospheric pressure and the brakes applied. To release the brakes it was only necessary to admit air to the train-pipe and so equalise the pressure on both sides of the diaphragms.

This form of vacuum had the same defects as the old-pattern Westinghouse; it was slow to act, and thrown out of action by an accidental parting of the train. In order to compete with the Westinghouse it must be made quick-acting and automatic. This was managed in a very simple and yet effective way. Imagine under each carriage a large vertical cylinder, closed at both ends, and containing a piston made airtight by a rubber ring rolling between it and the cylinder walls. A piston-rod passes out through a "gland" in the bottom of the cylinder, and is attached to the brake levers. The weight of the latter keeps the piston normally in its lowest position.

Now, suppose that air is pumped out from above

the piston. It will rise as soon as the pressure on its under side is sufficient to overcome the weight of the brake-tackle. If air is admitted again it will fall. As long as the pressure is the same on both sides of the piston, it obviously will not move. The problem before the engineer was therefore this:—how to arrange matters so that a vacuum may be maintained on *both* sides of the piston while the brake is *off*, and in the upper part of the cylinder only when the brake is to be applied. The train-pipe was therefore connected by separate channels with both the top and the bottom divisions of the cylinder; but that leading to the upper part contained a ball-valve, which fell back on to its seat as soon as the pressure on both sides of the piston was equalised. Though it would allow air to be *sucked* through it, it would not permit any air to pass it on its way to the upper part of the cylinder, excepting when the ball was deliberately displaced from its seat by means of a little lever fitted for the purpose of taking the brakes off a car when out of use or when being shunted.

We will, then, again picture a train leaving the running sheds for its day's work. The brake cylinders are full of air till the driver sets his exhauster going and empties them all. While running, the train-pipe must be *kept* exhausted. The admission of air to the train-pipe, by bringing atmospheric pressure to bear on the underside only of the pistons, at once causes the latter to rise with a

force proportionate to the quantity of air admitted. Any parting of the train would, of course, put on the brakes at once.

Extensive trials of the vacuum automatic were made in 1901 on the Austrian State Railways in both level and hilly country; and as a result this brake has been largely adopted in Austria.

On the projected electric monorail track from Liverpool to Manchester, the inventor, Mr. F. B. Behr, proposes to reinforce the air with an electric brake "composed of magnets eighteen inches long, exerting on the guide rails, by means of current generated by the reversed motors, an attractive force of 200 lbs. per square inch. One great advantage of this brake is that its efficiency is greatest when the speed of the train is highest and when it is most needed. The united brakes are expected to stop the car in half the distance of the Westinghouse alone, but they would not both be applied except in emergencies."[1]

Mr. Behr calculates that the two brakes together would arrest a train travelling at 110 miles an hour in about 500 yards!

[1] "The Romance of Modern Invention," p. 265.

CHAPTER XIII

ACCIDENTS AND THE BREAKDOWN TRAIN

In spite of the utmost watchfulness and care taken of signals, track, and rolling-stock, "accidents will occur" on the railway as elsewhere. Scarcely a week passes without the papers bearing in large type "Terrible Disaster to an Express," or "Fatal Collision"; and there follows an account of how some unfortunate beings were hurried into eternity amid the crash of the wrecked trains; and others, scarcely more favoured, suffered agonies beneath the débris while willing hands worked desperately to rescue them.

Yet the percentage of accidents is small, even wonderfully small, when one considers the nature of a train tearing along at terrific speed, across innumerable points; through busy junctions; along high embankments liable to slip; under bridges that after all are only brick and mortar, and subject as such to deterioration; round "blind" curves; through cuttings from the sides of which a tree or boulder might so easily fall; over a hundred trestles and girders of wood or steel; and all this by night as well as by day. Carelessness on the part of driver, signalman, coupler, axle-greaser,

platelayer, or crossing-tender, may so easily have disastrous consequences ; and even when all do their duty axles or wheels may be faulty. Then there are the elements to reckon with—water, that in the darkness of the night may have swept away a piece of the track, as happened a few years ago on the London and North-Western on the North Wales coast ; and wind, which sometimes lifts a train bodily and hurls it from the rails. Yes ! there are plenty of possible causes for an accident, so that one may marvel with reason at the rarity of railway disasters in proportion to the number of journeys safely made. On referring to statistics, we find that in 1896 only one passenger was killed out of 196 millions who travelled over British rails, while but one in $2\frac{1}{2}$ millions was even injured. There is therefore little need for anxiety while travelling ; since it has been proved that a railway carriage is far safer than a London street. A *bed* is the most dangerous of all places, Mark Twain humorously remarks, because the majority of mankind die there !

With the exception of a shipwreck or a big fire, few catastrophes are so dramatic as a railway "smash." It is so terribly sudden. In a couple of seconds the unsuspecting travellers are hurled into such a scene of destruction as will haunt them all their lifetime, if they escape alive. Occasionally, as in the case of the Tay Bridge disaster, not a soul lives to tell the tale. At other times—we may instance the Abergele accident—the dread Fire Fiend is awakened. That

pitiable occurrence has marked August 20, 1868, with a black cross in railway annals. The Holyhead mail dashed at full speed into some trucks laden with oil, which had somehow got loose on an incline. Only three carriages were derailed ; but the engine had smashed open the petroleum barrels in the wrecked trucks, and almost instantaneously hundreds of gallons of petroleum were ablaze, wrapping the train in a fearful robe of fire. Twenty-eight persons, including Lord and Lady Farnham, were burnt to death. All that remained of them and theirs was a few calcined bones, among which were found precious jewels, unharmed by the intense heat that had fused the settings.

Almost more terrible was the fire in the Paris Metropolitan Railway, which occurred as recently as August 1903. The conflagration originated in the leakage of the electric current propelling a train, which was not only arrested in the middle of a tunnel by the failure of its motive force, but also ignited. The tunnel acted as a chimney to fan the flames, and in a few moments they had seized the whole train. Many of the passengers were overcome by the tremendous heat and the gases created by the combustion of the sleepers, before they could struggle to a place of safety. A very similar accident happened, with similar results, on December 23, 1901, in a tunnel of the Liverpool Overhead Railway. In addition to the horrors of burning and suffocation, those of electrocution are added on an

electric railway, since the fugitives cannot see the "live" rail as they stagger along in the darkness. For the avoidance of such accidents, Mr. George Westinghouse recommended that the motors should be placed at the ends of a train only; that the amount of current supplied to each section should be limited, so that in the event of a short circuit (*i.e.* leakage) on the train, the current may be automatically and instantaneously cut off at a point some distance from such section of the "live" rail. Electrical engineers generally also advise the installation of the motors in absolutely fireproof cars, sheathed with steel and lined with asbestos; the provision of emergency exits at the rear of the train; and the location of the "live rail" outside the track so as to leave the four-foot way unencumbered and safe.

The disaster at Thirsk on the North-Eastern Line, which took place on November 2, 1892, is notorious as another instance of the devastating effect of fire in a collision. The fact that it happened during the night, and resulted from a pathetic incident in an overworked signalman's life added further notoriety. The signalman, James Holmes, had just lost his child, and on account of his mental distress had not been able to get a proper amount of rest between his twelve-hour shifts. When he entered the box to work the night express traffic he felt quite unfit for duty, and asked to be relieved, but it so happened that relief could not be sent.

The Scotch express, southward bound, was being run that night in two parts. The first part cleared the box safely. Then a goods train, waiting on a siding, should have been allowed to run through his block before the second half of the express. Unfortunately he fell asleep over his levers, and being suddenly startled into wakefulness by the "Be ready" signal from the next box, which referred to the express, he forgot about the held-up goods and lowered the signals. The goods driver, thinking that they were meant for him, drew out on to the main line, just in front of the express, which also interpreted the signals to mean a clear line for it. When the smash came the driver of the express had a marvellous escape, being flung over the fence into a field. But the passengers did not fare so well. Ten were killed and thirty-eight injured ; two of the deaths being due to the fire that broke out among the wreckage, probably through furnace coals coming into contact with the woodwork of the forward carriages. A particularly sad feature of this collision was the fate of an officer in the 1st Royal Highlanders, who, after coming safely through the Soudan Campaign, was burnt to death, only his medals remaining unharmed to establish the identity of the victim. Lord Tweeddale, the chairman of the North British Company, escaped with a severe shaking, thanks to the strength of the Pullman Car in which he travelled.

The signalman was tried on a charge of man-

slaughter and found guilty, but received no punishment, since his case was considered a particularly hard one. To avoid the recurrence of such lapses from duty the Company decided to increase the number of relief signalmen over their system. A further result of the accident was the stimulus that it undoubtedly gave to the movement for shortening the hours of a signalman's "shift."

Though the loss of human life is the most terrible feature of a collision or derailment, the financial loss proves, in a strictly pecuniary sense, the most grievous burden to the Company concerned. Thus, after the Thirsk affair, £25,000 had to be devoted to the payment of compensation to the injured passengers, and to the next-of-kin of those killed. In other words, a five-per-cent. dividend was at one blow knocked off 5000 shares, having a capitalised value of £500,000. We can easily understand, therefore, that the Company finds it to its own interests to take every precaution against such disasters as the above.

In the United States many an accident has been due to the collapse of the gigantic trestle bridges which span ravines and rivers, especially where the structure has been one of wood, or where it crosses a stream liable to heavy floods. A friend of the writer, while touring the States with a theatrical company, relates the following story, which gives a good idea of the risks that are run sometimes to keep an engagement. The train was approach-

ing a large city where the company had to play that evening, when the engine-driver saw that the bridge leading into the city over the river on which it stood had been almost submerged. A consultation was rapidly held as to the prudence of attempting a passage ; and meanwhile the waters rose above the track, so that it now became impossible to see even whether the bridge were still complete. The manager decided to take the risk. The driver let his engine go, and the train slowly advanced into the flood. The bridge vibrated with the swirl of the torrent in a manner most terrifying to the passengers ; and you may guess their relief when the train reached firm land on the further side. Very shortly afterwards the structure gave way. A few moments sooner, and the Tay Bridge disaster would have been repeated, with even more appalling results.

Another foe that the train-man has to fight is fire, the raging, relentless blaze that sweeps over the prairies or through the forests. Here is another little incident told to the writer by one who was on the spot. The name of the railway will for charitable reasons be withheld. Anyway, it was a great transcontinental line, and it passed through a forest-clad mountain range. The very first "through" passenger train that ran over its metals encountered a terrific forest fire, which compelled it to stop and the passengers to flee for their lives. In an hour only some twisted metal-work remained

where the fine express had halted. One of the passengers, rushing back to recover a valise, found a man lying insensible on the floor of a car and hauled him out just in time to escape the most horrible of all deaths.

The next train was, of course, also compelled to stop, and to clear the track of the remnants of its predecessor. As a precaution trucks were sent flying down the grades in advance to see if the way was safe. Fires still smouldered at many points, and were fanned into activity by the draught of the passing vehicles, proving that their despatch had been a prudent measure.

On heavy grades a "runaway" is the driver's greatest fear. Should the brakes fail to act he will find his train rushing round the curves with an increasing velocity which he is utterly powerless to curb. In the Rockies and other mountainous districts, "safety switches" are therefore provided, which will turn the train up an inclined side track if the driver is not able to stop and dismount to put the points over.

Cases are on record of a car actually jumping off the rails and re-railing itself; and of an engine cutting its way clean through a heavy obstruction thrown maliciously or accidentally in its way. In the majority of instances, however, derailments and obstructions lead to disaster, as might naturally be expected. That there should not be more fatalities under the latter head is a matter for some surprise,

since it is no uncommon thing to read of men or boys being arrested for placing sleepers, stones, iron, chairs, &c., on the metals, often with the avowed purpose of seeing "what a really good smash looks like!" In these lenient days such villains often get off much more lightly than they deserve; since the railway authorities do not wish to bring the facts before the public, to raise fears in the minds of their passengers. A liberal application of the "cat" is the least punishment fully earned by the would-be train wrecker.

Avoiding any attempt at a detailed list of accidents, which make a sad and morbid chapter in railway history, we may turn to the appliances provided for the removing of débris from the line and the giving of succour to the injured. A "railway ambulance" is generally to be found at an important depôt, ready for work, like the fire-engine, at a moment's notice. You may have noticed in a siding a crane mounted on a flat carriage, to which are coupled five or more vans. There is nothing at all romantic about the external appearance of the outfit; but a peep inside those closed doors would at once give you some idea of the work which a breakdown train may have to do.

We will suppose ourselves privileged persons who have the keys to these vans.

One of them is the riding van, in which the breakdown gang are hauled swiftly to the scene of action. Formerly the crew had to cling as best they

Photo by] [*F. Moore*

The Thirsk Accident on the North-Eastern Railway, November 2, 1892.

Ten passengers were killed and thirty-nine seriously injured. A careful examination of the picture will give a good idea of the destructive energy of an express.

[*To face p.* 208.

might to any part of the crane, the engine, or the trucks ; nowadays it is recognised that exposure to the weather during the journey does not render their labour any more efficient when they reach the spot where it will be required ; and a "coffee van" is provided. Peeping in, we see that its central object is a stove to which an oven is attached so that the men may heat both food and drink as they travel. A writer in the *Strand Magazine*—from which the author is kindly permitted to quote—thus neatly describes the fitting up of the van :—

"The van is capable of holding forty men. One end is fitted with cupboards, which, when opened, disclose flags, fog signals, signal and roof lamps used for lighting and protecting the train, as well as train signal lamps, ready trimmed for lighting, and four train lamps. Box seats are constructed around the sides of the riding van, which serve as receptacles for various tools, such as wood 'scotches,' small 'packing' shovels, hammers, bars of many kinds, and a large variety of 'sets.' The 'set' plays a very important part in the labour of clearing the line or rescuing imprisoned victims of a railway disaster. It is used for cutting shackles or bolts, and is a piece of sharpened steel resembling the head of an axe without the handle, from one to three pounds in weight. A piece of hazel, commonly called a 'set-rod,' is wrapped round it, and the two ends form a handle. The set is held on anything which it is required to cut, and with the blows of a heavy

hammer in the hands of those accustomed to such work it will quickly sever any bolt or shackle. Shovels, hammers, chisels, bars, and other implements are also ready to hand in this van. One cupboard contains the hand-lamp needed by the official staff, each lamp having the name or the initials painted thereon. Still another cupboard is labelled 'Ambulance.' The foreman opens the doors and reveals two tourniquets, half-a-dozen compressor bandages, scissors, forceps, adhesive plaster, lint for dressing, splints for broken limbs, antiseptic fluids, sal volatile, needles, sponges, basins, while an ambulance stretcher is folded away in one of the lockers. Another locker contains the necessary food and provisions, bread, butter, tea, coffee, sugar, and last, but not least, tobacco. This hasty inventory omits many articles of importance, but we must move rapidly on to the next van, merely noting the curious fact that the greatest number of the tools which have handles are painted a bright vermilion, so as to be easily distinguishable in the dark or in the confusion which attends a wreck on the line."

Even more interesting than the coffee- is the tool-van. This is the counterpart on wheels of the *Vulcan*, known among bluejackets as the "Nurse of the Navy." Our authority continues:—

"The tool-van glitters and bristles like an armoury. The floor is divided into little streets and squares, formed by rows of jacks, ramps, and

pyramids of chains, each placed with due regard to neatness and to prevent confusion and intermingling. The upper portion of the sides of the van is looped around with strong cables of rope or chain for haulage purposes, and is also arranged and fastened with occasional lashings to be easily loosened ready for use.

"A couple of sets of strong ladders are lashed to the roof. These are fitted with socket ends, and when, in event of a collision, waggons are piled up to a height of 20 or 30 feet, they are of the utmost service in scaling the wreck. The lower sides of the van are devoted to an array of single and double hooks, and huge iron loops for the jacks. The remaining space in the van is filled up by bars, levers, and other appliances, all arranged in an orderly fashion. Order seems to be the guiding motto in the breakdown train. There are in this van no lockers, for the reason that miscellaneous articles get out of ken when hurriedly thrown in, and are afterwards urgently needed. At one end of the van there is an 8-inch vice, secured to a bench, specially constructed, so as to be portable if required ; and a tool-rack, containing files, chisels, and hammers, every article being within easy reach. Before taking leave of this section of the breakdown train let us not fail to notice the hue of the paint on the inside of the van. It is a clear white, the object being to throw every article into greater relief, for every jack, every

lever or wrench, is painted a ruddy vermilion. The object is, of course, to indicate its locality when in a half-buried state. Otherwise after the confusion and strenuous toil of a breakdown, especially at night, a number of the tools would be lost or mislaid."

The crane, which forms so important an item in the outfit, is usually worked by steam, sometimes by hand. It has a lifting capacity of anything up to 15 tons, though seldom called upon to move more than a third of that weight. It can pick up anything within a radius of about 20 feet from its central point; and when required to exert an unusually violent pull is held down to the rails by means of clips. On the North London Railway the crane is built into the locomotive.

When a collision or other type of accident has been telegraphed to headquarters, the breakdown gang are at once summoned from their beds or wherever they may be. They lose not a moment in getting ready for action. A locomotive is hitched on to the train and off it goes at top speed, every other piece of rolling-stock making way for it like street traffic gives place to the fire-engine. As it flies along, the foreman of the gang is making all he can out of the curt telegram that has been handed to him; and weighing the particular course that may be necessary for this particular case. Scarcely is the breakdown train at rest when the men swarm out, and, working with remarkable method under their foreman's direction, attack the

wreckage. Of course, any victims pinned beneath the débris must be their very first care; but scarcely less important is the immediate clearing of the line, the traffic on which may be entirely dislocated by but an hour's block. The foreman has to decide very promptly on his line of action. He must take the tangled skein at the point where it can be most easily unravelled. Telegrams rain upon him asking how long it will be before the line is clear: he sends back answers of a non-committal kind, and orders his men to sling trucks and carriages bodily off the track, with as little damage as possible. Chains are attached to the topmost vehicles of a pile to haul them down. Then the crane approaches and picks up anything free that it can reach and places it out of the way. Meanwhile special men are straightening or replacing twisted rails, packing the sleepers and setting the track right. When the wreckage, human and material, has been removed, and the foreman is satisfied that the traffic may be resumed, he sends word to headquarters, the men replace their tools in the van, after covering up the more valuable débris with tarpaulins, and depart to their well-earned rest.

A week later, as the express rushes by the spot, a curious passenger may put out his head and say, "Oh! this is where the accident took place! I don't *see* anything!"

No! because the breakdown gang does its work

thoroughly, and leaves no skeletons about to tell where the battle was fought. All the mangled mass of wood and steel has been burnt or removed to the shops to be repaired or broken up for other uses.

CHAPTER XIV

INDIAN RAILWAYS

INDIA has a superficial area of 964,993 square miles, and a population of 231 millions. Stated otherwise, it is nearly fifteen times larger than the British Isles, and contains nearly one-sixth of the human race. In addition to its many fine roads and waterways, it has 25,515 miles of railway, which is considerably more than half of the total mileage of Asian tracks.

The standard gauge is 5 feet 6 inches, and of this there are 14,089 miles. The metre gauge (3 feet $3\frac{3}{8}$ inches) claims 10,724 miles; and the balance is laid with a 2 feet 6 inches or 2 feet gauge. Owing to the peculiar conditions of finance in India, some systems are owned and worked entirely by private English companies; some by the State; some by State-assisted companies; some by native states; and three small lengths by foreigners.

As the average reader has probably little acquaintance with the Indian main lines, a few words will be devoted to a consideration of the chief channels of railway traffic. The great termini are, naturally, Calcutta, Bombay, Madras, and Kurachi, and to these should be added Delhi as the most important inland centre. From Calcutta radiate five chief systems.

The first runs north-east into Assam; the second north to Darjeeling, in the Himalayas; the third—most important of all, and known as the "East Indian Railway"—follows the Ganges Valley, *viâ* Allahabad, to Delhi, where it connects with a line pushing up north-west to Peshawar, on the Afghanistan frontier; the fourth runs due west to Nagpore; and the fifth follows the east coast to Madras, *viâ* Vizagapatam, and, in combination with another east coast line, opens a path to the Gulf of Manaar, between India and Ceylon.

Bombay is the terminus of four important lines—the Bombay and Baroda, taking traffic north-east to Delhi; the Great Indian Peninsula, which follows a north-eastern direction to Busawal, where the track splits, to Allahabad *viâ* Jubbulpore, and to Nagpore; the Bombay-Raipur, which at the latter town meets a line coming north-west from Madras; and a west coast line flanking the inner side of the western ghauts to Panjun, a Portuguese seaport.

Madras is connected with Calicut on the opposite coast by the line running through Trichinopoli, and with Bangalore by a shorter track.

The Indus Valley railway, starting at Kurachi, follows the river to Shikarpore—where it throws off a northern branch to Quetta, in Baluchistan—and to Mooltan, the junction of lines to Lahore and Jhelam, on the main Calcutta-Peshawar route.

These systems are the framework on which the railways of India have been built. In point of length

they will rank high among the big tracks of the world. Thus, from Calcutta to Peshawar is about 1600 miles; from Calcutta to Bombay, *viâ* Nagpore, 1000 miles; from Calcutta to Tuticorin (South Madras Presidency) 1700 miles.

The history of Indian railways opens in 1850. The need for steam communication between the different districts of Hindustan was, in a way, unique. England and Europe generally had, before the advent of the railway, a good system of roads connecting all the most important towns, and also a great mileage of well-worked canals. In Canada, the United States, and Siberia, the railway was the pioneer of population, being launched out into regions hitherto occupied by sparsely distributed nomad tribes. But in India there was a dense population already in possession of rich agricultural tracts, carrying on a fairly extensive internal trade; yet, with the exception of the rivers and a few unbridged roads, there were practically no means of communication at all proportionate to the size of the community.

Certain engineers, among whom Messrs. Stephenson, Chapman, and Andrew were conspicuous, saw that there was a great chance for the metal track. The second of these gentlemen proposed a huge scheme of railways extending over the length and breadth of the Peninsula; and, as in the early days of English railroad history, the "conscientious objector" was soon firing off his criticisms. Even men in high positions said that railways were not wanted

and could not pay. How could an English engineer hope to overcome native prejudice, superstition, and the "caste" distinctions which would prevent the Brahmin from riding in a vehicle that carried a "sweeper"? Even supposing that these barriers were broken down, how could the intense heat, heavy rain, and destructive wood-eating white ant be combated?

The answer has been sufficiently practical to convince the most pig-headed opponent. Twenty-five thousand miles of track; all castes riding cheek by jowl; ants scared off from the sleepers by the vibration of the passing train; mountains climbed; torrents spanned by some of the finest bridges in existence. The native, so far from regarding the railway as the work of the devil, arrives at the station hours before the train is due, lest he should possibly be late, wraps himself up and lies down to sleep on the platform, till wakened by the roar of the engine, and then scrambles for a seat amid a crushing and screeching that contains no sign of aversion to the fire-horse. The rajah, who considers haste beneath his dignity, comes in a more leisurely fashion, and if a little behind time, expresses indignation because the train did not await his pleasure.

It took some years, of course, to accustom the ignorant native to the new means of travel. At first he salaamed and fell upon his face when a train approached. But fear has now given way to a due appreciation of the locomotive, which enables him to

sell the produce of his little plot, and to find work more easily; carries him from place to place with ten times the speed and one-tenth the jolting of the cumbrous ox-cart; saves him from starvation when their countryside is smitten by a famine; and when the hand of death is closing round him, bears him off to a sacred spot where he may lay his bones among those of a million other worshippers. To many a poor pilgrim the railway is his last friend. "Found dead" is a frequent entry in the casualty lists of an Indian line. Death has outstripped the locomotive.

Rulers, too, have become the firm supporters of the Englishman's steel pathway. A pretty little anecdote is told about Shere Ali, formerly Ameer of Afghanistan, when he first travelled in a train. After examining the road, the carriages, the engines, and the workshops, he said, "No longer must we talk of Aristotle or Diogenes." To him the engineer in the "cab" was more admirable than the cynic in his tub.

To return to history. When Government took up the idea of transcontinental lines, it parcelled them out among different companies, which should construct a series of railways extending in a zigzag fashion across the Peninsula. Draw a line from Calcutta to Bombay; a second from Bombay to Madras; and a third from Madras to Calicut, and you will have the gigantic inverted Z of the original design. The natural configuration of the country presented some formidable difficulties. On the western

side the Ghauts had to be crossed; at many points broad rivers flowing in shifting courses made necessary bridges of great length; and in their vicinity the engineers encountered low swampy plains like those of Virginia, which compelled the construction of mile upon mile of viaducts. Last, and in some ways most troublesome, were the jungles, full of savage beasts and strength-draining fever. The engineer's custom is not to be daunted by obstacles; and in India he has certainly well upheld his traditions.

We might have added to the above list the absence of manufactured materials and plant, brick, stone, lime, timber, and skilled labour. Natives must be employed to work in tropical heat; and, as in Uganda, their training to do the simple tasks required took a considerable time. We cannot wonder at their want of complete comprehension of what was wanted of them, when we consider that an educated English engineer gravely stated that Indian railways should be hung on chains, to keep the passengers out of the reach of wild beasts!

One advantage of native labour is its extreme cheapness. A man who got fourpence a day did well—in a land where people live on a handful of rice with a little *ghee* to make it more palatable. As a set-off had to be placed the costliness of good timber for sleepers, which were imported, ready "pickled," from England. Of course, India has very extensive forests—do we not know the "Woods and Forests" as a branch of the Indian Civil Service?—

but until railways had been built the transport of native material to railhead was almost impossible. In like manner grease, oil, and other railway commodities were imported, in preference to drawing on distant Indian markets. So that, on the whole, the mileage cost rose to about the rates prevailing in Austria and Belgium, £18,000.

The pioneer lines were the East Indian and Great Indian Peninsula, starting from Calcutta and Bombay respectively. The former had, until 1857, its terminal station on the west bank of the Hooghly. In that year the fine bridge spanning the river was opened. It is 1213¼ feet long, and is made up of two 540 feet outside spans, and a central span of 120½ feet. With its approaches the total reaches 4932 feet, or nearly one mile. Considered as a whole, the "East Indian" was easily engineered, since by following the Ganges and valley it ran through level country. Only one tunnel, half a mile in length, had to be driven. But three great bridges, in addition to that over the Hooghly, were needed; one over the Sone, 4721 feet; and the Jumna bridges at Allahabad and Delhi respectively, 3235 and 2040 feet from shore to shore. The building of the Sone bridge was interrupted by the Mutiny, during which the resident engineer had to fight hard, aided by a small band of assistants, to keep the flag flying over his house until the British forces came to his relief. The Mutiny is said to have cost the Company no less than three million pounds, as the rebels took a wicked pleasure

in tearing up the permanent way and demolishing any stations that fell into their hands.

The first sleeper was laid in 1853, and two years later the rails reached to Raneegunge, 120 miles from Calcutta. From that point it was at first proposed to carry the track over a route to the south of the Ganges, but the engineers soon decided that the great cities of the valley could not be left in the cold—if such an expression can apply to a tropical country—and to the Ganges they kept close, until 1866, when the first Calcutta train entered Delhi.

Operations were simultaneously in progress on the "Great Indian Peninsula," which entailed in its construction some first-rate engineering. Thirty miles from Bombay, at Kolyan, the track divides, and attacks the Ghauts in a north-east and a north-west direction. The more northerly line, bound for Jubbulpore, climbs up the Thul Ghaut Pass for $9\frac{1}{2}$ miles on an average gradient of 2 in a 100 feet. The metals are doubled all the way, and to accommodate them two-and-a-half million cubic yards of hard rocky material had to be blasted away, including that of $1\frac{1}{2}$ miles of tunnel. The Bhore Ghaut Pass, to the south, is even more difficult with an equally severe gradient nearly double as long as that in the Thul. "The line is frequently carried clinging to the steep hillsides, with the inner portion of its formation surface notched or benched into the rock, whilst the outer portion is carried on artificial bank, having an enormous outward slope; or the outer

half may be supported by long lengths of masonry retaining wall built up from great depths below, or be carried on a series of arch vaulting planted against the slope."[1] In 1861 as many as 42,000 workmen are said to have been employed on this difficult grade —probably a labour record in railway history.

Once over the Ghauts the lines, both northern and southern, run for hundreds of miles across sandy plains, the monotony of which is only equalled by the persistence of the dusty clouds that penetrate every chink of the carriages and smother the heated passengers inside.

Among the many other feats accomplished in India by the engineer we can here notice but three, all notable for the manner in which they have overcome mountain barriers. First is the Sibi Railway, which has already been hinted at in connection with Russia's Transcaspian line. To find Sibi put your finger on Kurachi, and follow the railway that runs north through the Indus Valley till you reach Shikarpore; then take the left hand branch 133¼ miles, and you will be at the place you want. This last stretch, by-the-bye, was built in four months of 1879, when complications were feared on the Baluchistan frontier, in the face of great difficulties arising from want of food, water, fuel, and shelter; and constitutes a record for Indian platelaying.

At Sibi the line makes two separate curves to Bostan Junction on the Bolan Pass, 112 miles dis-

[1] "Ways and Works in India." G. W. Macgregor.

tant and nearly 6000 feet higher above sea-level. The more southerly loop passes through Quetta, and has a ruling gradient of 1 in 67. Thirty thousand men were employed on these loops, driving tunnels, making huge embankments, and building bridges and viaducts. The mortality among them, due to cholera-breeding heat and heavy rains, reached at times terrible figures. Neither natives nor whites were spared. Thousands of workers left their bones in the wind-swept passes along which the line now meanders over one of the most extraordinary tracks in the world, rivalling in its many twists and turns the St. Gothard approaches, and in the altitude attained the railways that cross the Rocky Mountains. From Bostan the way is now open to Kandahar, through the celebrated Khojak Tunnel, 2½ miles long. The line is, of course, the outcome of the military necessity for transporting troops to the frontier in case of trouble with the Russian forces which have already set their foot on the Afghan frontier: though in time to come it may be turned to purposes of trade and commercial intercourse. Quetta, which has railway connection *viâ* Shikarpore and Mooltan with Peshawar, is in an almost impregnable position, and will be a magnificent base for both offensive and defensive tactics; while its accessibility from the sea-coast would enable troops to be delivered there from England in twenty-five days.

The railroad scaling the Himalayas from Silliguri to Darjeeling had an entirely peaceful origin. It is

Photo by] [*F. Moore*

The Bombay-Calcutta Express.

It travels the whole distance of about 1,200 miles at an average speed of 25 miles an hour.

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due to the needs of the hill tea-plantation for communication with Calcutta, and to the longing for relief from burning heat that drives Anglo-Indians in thousands to the pleasure resort up among most magnificent views of the snow-clad peaks of the mightiest mountain range on earth.

Silliguri, 250 miles from Calcutta, is the meeting-point of the broad-gauge East Indian and the 2-foot track that in fifty miles climbs 7500 feet. Here passengers for Darjeeling enter the tiny cars, mere toys beside their big brothers of the wider gauge. The whole train, locomotive included, weighs but forty tons, as the gradient in places is 1 in 23.

For the first few miles the country is flat. The traveller notices the embankments on which the metals lie and the dense forests flanking them, intermingled with semi-tropical vegetation, and the home of gorgeously plumaged birds. Not so many years ago—even since the railway has been built—elephants, tigers, buffaloes, and deer wandered across the track; and it is on record that a truculent bull elephant once took up a position in the permanent way, and compelled a train to retire precipitately. Now, of course, the wild animals have learnt that it pays them best to keep far off the curious, panting creature that lumbers along like a gigantic snake.

From the point where the rise commences the difficulty of the engineer's task is very apparent. Surely no railway ever twisted and turned oftener than this impudent little track! It coils round a hill,

rising many feet each convolution. It creeps along the most terribly narrow ledges, which raise pictures of sudden death before the eyes of nervous passengers. Cool-headed folk feel confident that all is for the best, and admire the scenery, growing more wonderful every moment. Now the train arrives at a place where it has been impossible to plan a curve, and the ascent must continue up a series of zig-zags, terminated each end by a reversing station. Mr. A. Sarathkumar Ghosh thus tersely describes the operation in the *Wide World Magazine*:—"A number of ledges are cut on the side of the hill, one above another, so that the top of the lowermost is joined to the bottom of the one above it, and the top of this again to the bottom of the next, and so on." The motive power has, of course, to be transferred from end to end at each terminus, so that the passenger is travelling sometimes backwards, sometimes forwards. Engines wait on the zig-zags ready to couple to the temporary "head" of the train; and as soon as each has done its work it passes on the job to its successor. Occasionally two engines are required to get the few carriages up the slopes; and at a whistle "extra engines, lurking in ambush behind some mysterious corner, dash out at the distress signal, to push up the train from behind until the critical point is passed." Meanwhile the climate has changed considerably. The burning heat of the plains is now only a remembrance, and light clothing fails to keep out the cold breezes blowing from the eternal snows.

So at an elevation of 4800 feet a halt is made for a meal and a complete change of raiment, or at any rate for the donning of a thick overcoat. Nature, too, has noted the difference, and altered the fashion of the woods that mantle the hills. In place of the sal or toon tree rise serried ranks of oaks and pines, and the orchid is replaced by the rhododendron.

At 5000 feet clouds begin to gather. "At one moment the sun is shining brightly above us; then comes a cloud, and we are left in sudden darkness. We ascend a little higher—the cloud envelops us like a delicious cool mist, then passes away, leaving us in bright sunshine. We ascend yet another spur, turn round a corner; below us is the cloud covering the mountain side like a bundle of fleece. Suddenly there is a break in the range of mountains; down, down, forty miles away, we catch a glimpse of the plains below like a green cloth with a white chalk-mark meandering all along it—the united stream, the junction of whose tributaries we have just passed. Suddenly a dark cloud obscures the sun, its huge shadow rushes along the plains with a frightful velocity, and sweeps over stream and vale and mountain in one gigantic embrace. Thus we climb. Beauty upon beauty, grandeur upon grandeur, succeed one another in an endless panorama. The human mind is lost in an ecstasy of delight, and knows not which way to turn to admire. At last an altitude of 7500 feet is reached; suddenly, as we creep along the edge of a precipice, there bursts forth before our

startled gaze the first glimpse of the snow-clad Himalayas. It is a feeling of intense awe that subdues us at that moment, and the lesser joys of the journey are merged in a sublime contemplation. The railway still curls and curls before us for three long miles, while the snows appear, disappear, reappear, till the last curve is reached, and the train enters the spur on which stands Darjeeling, the 'Queen of the Himalayas.'"

Up among the hotels and tea-gardens the traveller may rest and drink the delights of scenery unparalleled. Or, if energetically inclined, he will climb on foot to a yet higher point, and from Tiger Hill catch a glimpse of Everest, a hundred miles away, the apex of the world, alone in the sublime majesty of its unequalled altitude.

To the commercial mind there is attraction in the great tea-plantations, which annually despatch ten million pounds of the fragrant leaf to cheer humanity. And the work-worn civilian or soldier finds renewed health for his body and mind in the magnificent climate of this lovely, salubrious spur of the Himalayas.

If you draw a line from Sibi to Darjeeling, and describe on it an equilateral triangle "on the side remote from" the Himalayas, the apex will fall somewhere near the Nilgiri Hills, which are the scene of a third marvellous railway. In India, where such tremendous elevations set the standard, a "hill" may be anything up to 10,000 feet in height, and the reader

must therefore substitute for it in imagination the more imposing "mountain."

The author is greatly indebted to Mr. W. J. Weightman, the engineer of the line, for information about this, one of the longest, if not actually the longest, of rack railways. "The line starts," he says, in a paper read before the Institution of Civil Engineers, "from Mettapollium, a terminal station of the Madras Railway in Southern India, and ascends nearly 5000 feet to the plateau on the Nilgiri Hills, on which are situated the important towns of Ootacamund, the summer headquarters of the Madras Government; Coonoor, and Kotageri, two European settlements, occupied chiefly by planters and retired officials; and Wellington, the military sanatorium for British troops in South India and Burma." As at Darjeeling, railway communication with the plains was most necessary for the transport of material down from, and the carrying of people up to, the high country. The first attempt made to build a line collapsed for want of funds. Then Government gave help, and sufficient money was raised to carry through the undertaking.

The Nilgiri Hills are, at the point where the rails climb them, about 5000 feet high. On their eastern flank the only way up is a narrow ghaut or valley, from which lesser valleys branch right and left. The railway is $16\frac{3}{4}$ miles long, the first $4\frac{3}{4}$, on a gradient of 1 in 40, being an ordinary adhesion line; while the remaining 12 miles are worked with a rack on the Abt principle up a uniform slope of 1 in $12\frac{1}{2}$, required

by Government conditions. The gauge is 1 metre, and in consequence no curve having a radius less than 328 feet could be permitted. It was therefore impossible to follow at all places the natural contour of the valley sides. Where a shoulder projected, a tunnel must be made through it; and in the case of a gulch, a viaduct would be needed. The difficulties encountered in the Bhore Ghaut, near Bombay, were met here also, on account of the many tunnels, deep cuttings, and viaducts, which made up nearly the total mileage of the line. The surveyors' hardest work was so to adjust the balance between cutting and viaduct as to ensure the most economical construction. This was done only after cross-sections of the whole route had been taken, in places but five feet apart longitudinally. Owing to the gradient being fixed, the engineer could not make the incline a little steeper at particular spots to save a considerable detour.

"In several places the ground was so difficult and inaccessible," says Mr. Weightman, "that a very careful and elaborate triangulation, plotted to a large scale, was necessary in order to locate the line. The most troublesome places were the Benhope cliffs, where the line passes for 1000 feet along the face of an almost vertical cliff 2000 feet high, and the Burliar valley, where it crosses a gorge by a bridge 150 feet long and 120 feet high, and then immediately enters a tunnel 275 feet long on the face of the cliff. In both places the survey was very difficult, and ropes secured to jumpers let into the rock

had to be used to get any foothold at all." No less than 40 million cubic feet of hard rock and boulders embedded in earth had to be shifted to make way for the rails. Dynamite was freely used, and the workers had to be very careful not to let any débris roll into the public road below, which for a considerable distance runs parallel to the line.

To prevent landslips in cuttings and on the embankments, their sides were planted with Guinea grass, which has very long and tenacious roots, and holds earth together more securely than any artificial device; though in places, where the cutting had almost perpendicular faces, retaining walls of great length and solidity were built.

Probably no line of equal length has more bridges than this, which is carried over 23 large and 113 small ones, none of them longer than 450 feet, but some 120 feet high. Their construction was complicated by the curvature and steep gradient of the track, tending both to push them outwards and to cause the girders to slip down hill. To prevent downward movement each girder is fixed only to its lower pier on the incline, the upper end being free to allow of expansion.

The rack-bars, two in number, are laid centrally between the rails, except on severe curves, where it has been found expedient to slightly widen the gauge and yet keep the bars the same distance from the outer rail. The bars break pitch—that is, a tooth of one is opposite a slot in the other, and *vice versâ*—and

also break joint, in order that, if either bar gives way, the engine pinion may still have a hold. Perhaps the reader will be interested to learn how this sort of track-laying is conducted, so some particulars are added. "The bars"—Mr. Weightman is once more our authority—"are of flat steel, with a tensile strength of 30 tons to the square inch. The greatest care was exercised in making them, as regards pitch, shape of teeth, length of bar, and position of bolt-holes. Every bar was applied in the works to a metal stud template, to test its accuracy, before it was accepted. The rack is carried by cast-iron chairs, which are fixed to the sleepers by two fang-bolts. The whole of the permanent way had to be laid with the greatest exactitude; all the rails were bent truly to the curves by machine; and the laying of the track itself was a somewhat troublesome process. The spacing of the sleepers is fixed absolutely by the rack, and owing to the use of deep fish-plates, it became necessary to have the rail-joints not only square with each other, but also exactly midway between the two adjacent sleepers. There was no difficulty in doing this on the straight, but on curves it was necessary to use rails of different length for the outside and inside. Rails of the required lengths for all the different curves were cut, drilled, and bent by machine in the depôt, and were painted different colours and stacked separately, a table being given to the man in charge of the rail-bending machine showing measurements required for different curves.

"The platelaying procedure was as follows:—Sleepers, with rack-chairs attached, were spread loosely ahead correctly spaced; a second gang followed, fixing the rack loosely; and the straightening, adjusting, and tightening of it were done by a third set of men following. Special care was given to the joints; a steel stepping-gauge, embracing three teeth of each rack, was left in the rack at the joints while the fish-bolts were being tightened up. Two gangs followed, laying the adhesion-rails, the special points in which care was needed being to keep the rack truly in the centre of the gauge (on the straight), and to keep the top of the rack exactly the correct height above the top of the rails. This latter is an important point, for if the rack is too low, the pinion cannot engage properly, and if it is too high, there is danger of it jamming. The laying of the track was kept 100 feet or 200 feet ahead of the rails, an attempt to lay the adhesion-rails first and the rack afterwards proving unsuccessful. The platelaying was done telescopically, as it could only be commenced where there was a break of rack, and could not proceed in both directions on account of the difficulty of correctly junctioning the pitching and stepping of the rack-bars."

The sleepers are made of a hard Indian wood of a very durable character. Usually steel is employed for the purpose on rack-railways. Mr. Weightman claimed for wood that it gives a more elastic road, and is easier to handle.

A few words about the engines, which are always at

the downhill end of the train. They are of the Abt "combination" pattern — that is, they can work on both plain and rack rails. There are four cylinders —two large, outside, for the adhesion-wheels; two small, inside, for the rack pinions. Each engine has six wheels, 2 feet 6 inches in diameter, and weighs 33 tons. To minimise friction at the curves, a jet of hot water is squirted under the wheels.

The trains are well provided with brakes. The engine has, in addition to the vacuum—which also controls the carriage wheels—a hand-brake to govern the rack pinions, and, as a further precaution, the Chatelier air-brake on both sets of cylinders. This last brake, peculiar to very steep grades, is worked by reversing the engine and opening the cylinder-cocks. The cylinders then become air-pumps, and the pressure against the pistons helps to retard the train.

The line cost, on the average, about £15,000 per mile. The metals will presently be extended from Coonoor, the existing terminus, to Ootacamund, a distance of about 11 miles, rising 1000 feet to the crest of the watershed, and then dropping 200 feet into the town. For this section an ordinary adhesion track will suffice. Lovers of animals—and we will assume that all readers are such—will be glad to hear that the railway has benefited not only man, but also the brute creation, since no longer are vehicles hauled up the steep mountain road by wretched little ponies, whose life was made a grievous burden for them to bear by the heavily-laden passenger car lumbering at their heels.

CHAPTER XV

THE RAILWAY SURVEYOR AND ENGINEER

It is said that the Germans owed their victory over the Austrians at Sadowa, in 1866, to the discovery made by a scout on the eve of the great decisive battle. He was performing his usual duties when, much to his surprise, he saw the Austrian army on the further side of a hill beneath which the Germans were encamped, unconscious of the proximity of their foes. He at once sent back word to camp; the German dispositions were quickly made; and the following day the Austrians found themselves enveloped on every side.

The scouts thrown out in advance by the promoters of a railway play a part as important as their military brethren. They are called surveyors. Their business is to spy out the land over which it has been determined to run the rails, measure distances, heights, curves, note all rivers that will require bridging, all hills which may necessitate a tunnel, and spare no pains to decide upon the most favourable, and at the same time economical, route for the railroad builders to follow.

The difficulty of their task varies greatly with the nature of the country they have to survey. In most

parts of England, for instance, the track may be located and its gradients determined very easily by the aid of an ordnance map and a mere "reconnaissance." Certain towns or villages must be passed through, and the exact path of the rails is settled by agreement between the owners of property and the railway company concerned. But when mountainous or little known districts have to be examined, the duties of the surveyor become much more onerous. He knows that he holds in his hands the fate of, maybe, several millions of pounds sterling; for if his observations and calculations prove faulty after the track has once been laid, many miles of road may either have to be abandoned or entirely reconstructed at enormous cost. Such a thing has happened not once nor twice in railway history; and it has become a maxim among engineers that, while a cheaply built line can be rebuilt, there is little or nothing to be done with a line that has been badly located.

As a consequence, the directors or promoters of a railway spend large sums on their preliminary surveys. Men are sent out to explore a thousand square miles of territory, perhaps, and draw up very careful reports of their experiences. It has already been mentioned that before the Canadian Government finally decided on the route for the Canadian Pacific Railway it had, to guide its judgment, the reports of men who for seven years had penetrated the Rockies at many points, and taken their instruments over wide expanses of prairie. And even after Mr. Sandford

Fleming, the surveyor-in-chief, had sent in the collected reports—which cost £700,000 sterling—it was found necessary to disregard them when certain portions of the track were ultimately laid.

The surveyor must be a man of great physical strength; for he works many hours a day, and in all kinds of weather. He must possess considerable tact to overcome the prejudices of people who see in him and his party the shadow of coming events that will disturb the countryside. At times he is required to show great nerve, when dangling at the end of a rope over giddy precipices, or crawling along narrow ledges where the slightest slip may mean destruction. Patience and accuracy also should distinguish his work, since hurried calculations are distasteful to his superiors, and will prove broken reeds to lean upon when he has to make out his plans and sections. On the whole, therefore, his life is a hard one; though his work passes unnoticed except by the men who employ him. While the railway is in course of construction public attention fixes its eyes on the wielders of pick and shovel, or the bridge-builders, or the tunnel-drivers; and after the rails have been opened for traffic the engineers who directed the army of workmen receive the credit. But few travellers think of the days spent by the surveyor in a country where, perhaps, his life was endangered many times during the twenty-four hours. When generals have won victories the scouts are forgotten.

The surveyor's party consists of flag-men who lead the van with axe-men to clear away trees and bushes which may interfere with observations made by the transit-man and the leveller, who respectively record the horizontal angles for the curves and the vertical angles for the gradients. The levelling instrument used is such as we often see at work on the public roads. One man carefully adjusts the tripod and with the aid of three screws makes the table on its top perfectly horizontal. He then peers through the swivelled telescope attached to the table, and focuses it on a graduated rod carried in advance by his helper. Four little steel points, projecting towards the centre from the inside of the tube, tell him exactly at which figure the telescope is pointed. Knowing the height of the telescope from the ground, and the distance from the tripod table to the rod, he can easily calculate the rise or fall of the gradient between the two points. For very mountainous country, where it is difficult or impossible to proceed straight ahead by regular or uniform stages, trigonometrical measurements are made with the theodolite, a much more complicated piece of mechanism than the ordinary level or transit instruments. The surveyor measures a "base line" and goes over it again and again until satisfied of its exact length to a very small fraction of an inch. He then has an observation flag or pillar set up at a point on the projected track, and transfers his theodolite from one end of the base to the other, noting the angles made at each extremity with the

base line when the telescopic attachment has been slewed round to centre on the pillar. He now is in possession of three of the six elements of a triangle, viz., the base and its two adjacent angles, and can easily calculate the dimensions of the other three. These serve as data for further calculations, both vertical and horizontal.

At the end of a day the chief leads his men back to camp, collates their reports, and draws out a map or profile of the day's work. If these can be improved upon he will go over the same ground again on a different line, and repeat the process perhaps three or four times till satisfied that no further improvement is possible. He then forwards his papers to the engineer-in-chief of the railway, who sometimes accepts the surveyor's suggestions just as they stand, and at others draws out a new route for examination.

In America, as we have already seen, the surveyor's work on the pioneer transcontinental tracks was rendered very exciting and perilous by the raids of Red Indians. It required no ordinary pluck to penetrate, almost single-handed, into regions where the white man was still regarded as an interloper and therefore a proper subject for the scalping-knife. At night, when the camp-fire was lit, a keen lookout had to be kept for the Indian who would creep up with tomahawk and bow, ready to deliver his attack in the first unguarded moment. It was very hard for men, tired by their daily toil, to be constantly on the watch for an enemy who could take his sleep when he

chose; and only too often the whites had to pay the extreme penalty of yielding to overpowering drowsiness.

The most tragic chapter in the whole history of railroad surveying had its scene in the Sahara. The French have long desired to throw a railway across the desert sands, with the double object of aiding the subjugation of hostile tribes and of opening up a commercial route between their Algerian provinces and those on the Congo or Niger.

In 1880 a surveying expedition was sent under Colonel Flatters to explore the Sahara and decide upon the easiest and most profitable route for a track. It pushed some distance into the desert, and returned with sufficient information to encourage the Government to countenance a more exhaustive survey in the following year.

Now the Tawareks, and their neighbours the Shaambah Arabs, foreseeing that the arrival of the iron horse would not be to their advantage, as the bandits of the deserts, for the time buried their long-standing feuds, and decided to oppose this second survey in the most effective manner possible, by killing off all the French party.

The latter was, unfortunately for the prestige of the hated Frank, badly organised and led. It managed, indeed, to penetrate 800 miles into the Sahara, as far as Tadjenoût, an oasis in the Ghat region. Then the Shaambah guides betrayed their employers into the hands of the Tawareks. Suddenly from out the scrub

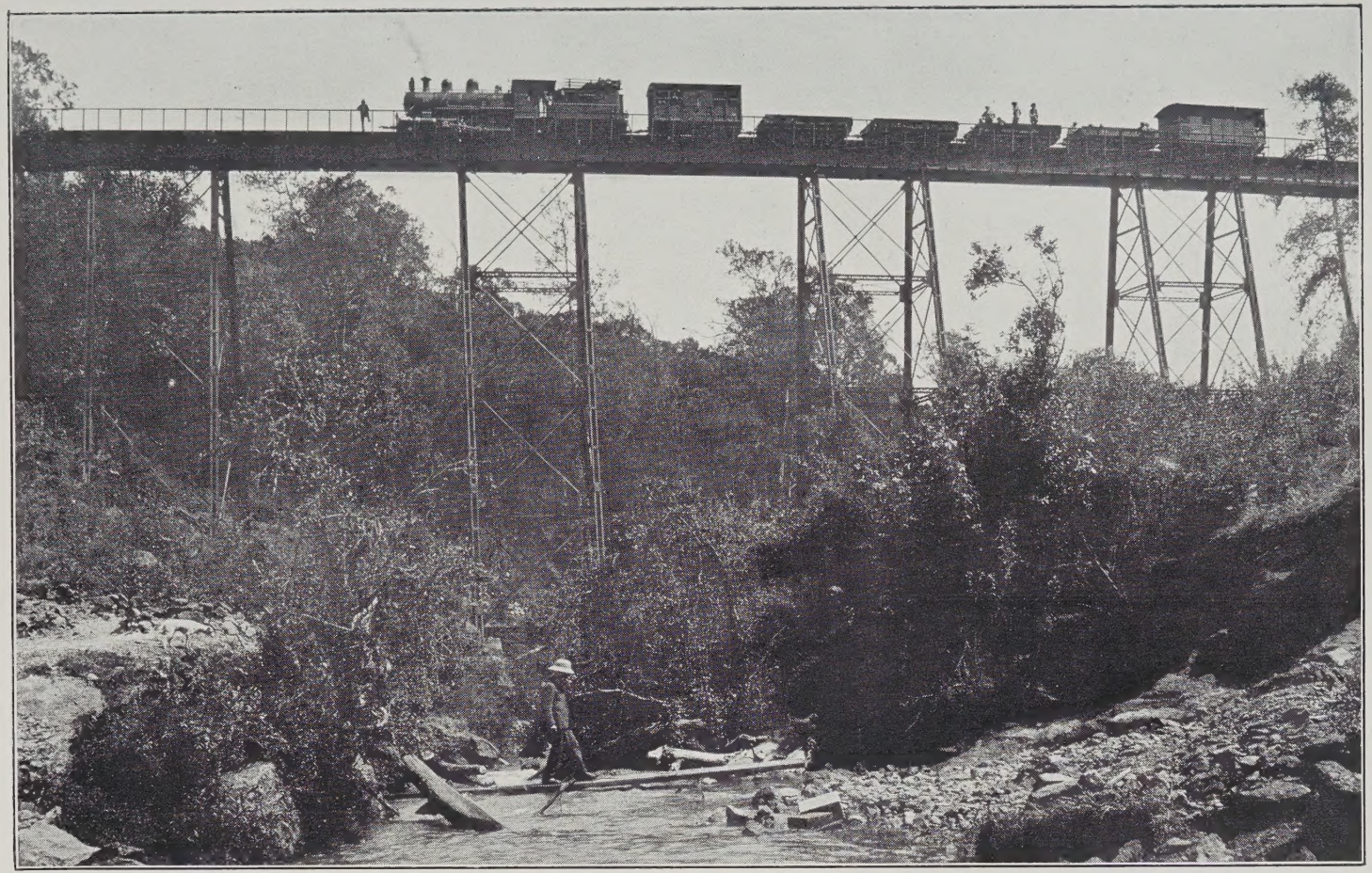


Photo by] [*W. D. Young*

An American Steel Viaduct on the Salisbury-Beira Railway, Mashonaland.

[*To face p.* 240.

appeared a band of three or four hundred warriors, who wiped out a small party consisting of Colonel Flatters and four companions, besides capturing the camels and slaughtering their drivers.

As soon as this disaster was known in the main camp, the officers there held a hasty council and decided upon an instant retreat. They broke open the cases of ammunition and food and divided the contents among the survivors, who, under cover of night, began their desperate homeward march. Theirs was a sorry plight—an insufficiency of supplies, no animals to carry water, and the terrible desert to be crossed; while the relentless enemy hanging on their rear left them no peace either by night or day.

To hurry on the inevitable end, the Tawareks pretended to bury the hatchet, and offered to supply the starving men with dates—the staff of life in the Sahara. These were readily bought and greedily eaten. Only then did the treachery of the Tawareks become evident. The dates had been impregnated with a vegetable poison, which caused the wretched eaters to rush up and down in agony, praying for death. Some, including the commander, went mad, and shot off their firearms in all directions. When these distressing symptoms had been somewhat alleviated by draughts of warm water, the march was resumed to the wells of Amguid, which the enemy had already seized. A sharp engagement dispersed them, but not until all the Europeans but one had fallen. The Tawareks now let the desert do its work

among the survivors, who were reduced to such extremities that they actually killed and ate any of their number who fell exhausted by the wayside.

Eventually only a handful of Arabs arrived in French territory bearing the news of the disaster, which was received in France with great indifference. No expedition was sent to restore the prestige of the French military forces, now severely discounted by this reverse. The Tawareks rejoiced over their victory, and issued their own version of the affair in a letter to the Emir of Ghadames: "Colonel Flatters came to us with his soldiers armed with fifteen hundred and fifty cannons, with the intention of crossing the country of the Hoggar, to go to the Sudan. They actually came to the Hoggar, but the people of that country fought them in the Holy War in a most energetic manner; they massacred them and made an end of them. Now it is absolutely necessary, oh dear friend, that the news of our great deeds should come to Constantinople. Tell them there what has happened, that is to say, that the Tawareks have carried on the Holy War against the Christians in the most exemplary manner, and that God has helped them against the Christians to destroy them. But now, if the Christians are permitted to travel among the Tawareks, that will be a very bad thing for us, for us who have fought in the Holy War."[1]

Thus ended this disastrous incident. Whether the

[1] "A Search for the Masked Tawareks," by W. J. Harding King, F.R.G.S.

French will persist in their schemes on the Sahara until their locomotives run from the Mediterranean to the Congo, remains to be seen.

Nature can be as terrible a foe as man, for nothing can move her pity. To overcome her requires careful and scientific preparation, combined with the utmost caution. Mere bravery will not take a mountaineer to the summit of Mont Blanc or Aconcagua, or across the sandy terrors of the Gobi Desert, or through the floes of the Polar regions.

The truth of this was brought home in a most lamentable fashion to the surveying party which, under the leadership of Mr. F. M. Brown, essayed the descent of the Colorado River in 1889.

Twenty years earlier Major Powell, of the United States Army, had managed, after many hairbreadth escapes and severe privations, to navigate the whole chain of Canyons, in specially built boats with airtight compartments fore and aft. After a lapse of two years he made a second descent, as far as a point in the Grand Canyon, where circumstances obliged him to abandon any attempt at further progress. To Major Powell belongs the honour of first successfully braving the terrors of these rock-bound gorges.

The natural beauty of the Canyons, among other things, suggested to Mr. Brown the desirability of a railway that should run from Grand Junction, Colorado, to the Gulf of California. The track was to be laid in the gorges at a sufficient height above normal water-level to protect it against heavy floods. The

scheme was foredoomed to failure, and there is at present no prospect of its revival; but the circumstances of the preliminary survey are such as to merit a short description.

For the grim struggle with the river six boats were prepared. The leader, in designing them, had unfortunately not made sufficient use of the valuable experiences of Major Powell. The boats, being constructed of cedar instead of oak, proved quite unequal to the buffeting that they had to encounter in the rapids and cataracts. They were also too small and too unstable. It is to be feared that the powers of the Colorado had been sadly underestimated.

On May 25th the crews, sixteen men in all, embarked on the Green River, as the main confluent of the Colorado is named. In order to avoid overloading the boats, a large proportion of the stores were formed into a raft and towed behind. On May 31st they reached Cataract Canyon, and began to manœuvre the boats through its perils. But the raft soon proved unequal to the journey; the cataracts seized it in their rough embrace and pounded it to pieces—a fate which all the boats narrowly escaped. One was overturned and carried thus for a mile and a half, its crew clinging desperately to its sides. The same day a second shattered itself on a rock. At the most dangerous part of the Canyon only four boats remained, and these were much knocked about. Provisions ran short, and a second peril, that of starvation, confronted the brave voyagers. The party therefore

separated, three boats pushing ahead in search of food, while Stanton, the chief engineer of the proposed railway, and four companions, remained behind with one boat to continue the survey. Fortunately for all concerned, a food-supply was soon discovered, and they had a chance to rest and repair the boats before entering the Marble and Grand Canyons. In the former gorge a terrible disaster occurred. Brown and another man were thrown out and sucked down by a whirlpool, never to be seen again. A few days after, two more of the expedition met their death in like manner ; and Stanton, now in command, decided to abandon the advance for the present.

By the end of November he was, however, on the turbulent waters again. But he had learnt his lesson, and the frail shells of the first voyage had been replaced by stout oaken boats, lined with air-tight compartments. The men were provided with cork life-belts, and all stores were encased in rubber bags to protect them against the bad effects of an upset.

Even under these more rational conditions the risks to be run were serious. In the Grand Canyon a rapid, falling eighty feet in 600 yards, was negotiated by letting the boats down on the ends of ropes attached to boulders or any other hold that offered itself. A boat was overturned, and the party had to enter the icy water to remove its cargo. One side of the craft being battered in, they were compelled to cut a section out of the middle and shorten the boat — soon afterwards splintered by a cataract

through which the crews sent it, hoping to catch it below.

The surveyors now experienced a sudden rise of the river, caused by a cloud-burst on the course of the Little Colorado. The water came down in the form of huge waves, foaming and roaring like ocean billows. Once again a scarcity of food compelled the party to separate into two divisions, one of which retired from the expedition. The rest pressed forward, running the rapids wherever possible. In the passage of one of these Stanton was flung out by a wave, and would have been drowned but for the cork belt which he carried. Finally, after many narrow escapes, the boats won to the quieter reaches of the river, and on April 26th met the tidal bore which rushes up the Californian Gulf almost before the ebb has ceased.

This expedition, though bent primarily on making a survey for the track of the iron horse, for the first time performed the remarkable feat of descending the Colorado from the Green River to the sea, a fact which may have slightly consoled the survivors for the loss of four brave companions. If indeed the engineer ever leads his rails beside those brawling waters, he will accomplish a task hardly equalled among the many marvellous feats already performed in the service of the locomotive.[1]

The survey of a line completed, the engineer-in-chief draws up detailed land plans, and invites tenders

[1] For many details of this account the author is indebted to Mr. F. S. Dellenbaugh's charming "Romance of the Colorado."

for the construction of the blocks into which the whole route is broken up. Contractors name the sums for which they are ready to undertake to complete a section in a certain time, a clause often being added that a bonus shall be given them for every day short of the stipulated time; while they, on the other hand, are generally bound to pay a fine for every day in excess. Tunnel-driving is perhaps the most risky undertaking that a contractor can commit himself to; for though he may calculate exactly the amount, and probably the quality, of the material to be removed, he is unable to ascertain beforehand that there are no unforeseen obstacles lurking in the strata through which he will have to hew his way. The Severn Tunnel and its Big Spring; the quicksand of the Kilsby tunnel, that broke one contractor's heart; the hot springs now being encountered in the Simplon, which in the "last lap" of the world's longest tunnel give a great amount of trouble, are good instances. Or again, a very wet season, such as that of 1903 in England, may occur, and cause landslips in great embankments which can be put right only at huge expenditure; or the human element may prove perverse, and go out on strike when the men think they have their employer in a tight corner, and make preposterous demands. We find men like Brassey, Peto, and Sir Weetman Pearson making huge fortunes over the undertakings they have successfully carried through; but many a contractor has found himself

hundreds of thousands of pounds out of pocket at the end of years of hard work and anxiety.

If versatility and resourcefulness are required in any man it is in the civil engineer. He must not only be thoroughly acquainted with the theory and practice of bridge building, tunnel driving, and the nature of all the different materials through which a cutting may have to be made; but he is often required to make a prompt decision in the event of some unexpected difficulty presenting itself. In this last connection we shall, of course, think of Brunel the elder pushing his way beneath the Thames by the aid of an air-tight shield which he invented for the occasion; and of George Stephenson filling in the Chat Moss with bundles of heather and wattles; and of Walker lining the Severn Tunnel shafts with wood to hold back the inrushing water. And are there not a hundred other instances written in the chronicles of the Engineers, all to prove their readiness to grapple with an awkward situation? It is therefore natural that we should find the "man in charge" often winning fame as an inventor of the steam-navvy, of the mechanical drill for boring the toughest rock, of the "traveller" which helps piece together the American bridge, of the pump which sucks silt from the bottom of a harbour, of the pneumatic caisson wherewith piers are sunk through the treacherous mud of a river-bed. It is to him that his subordinates turn for advice in time of trouble. He must be here, there, everywhere; ordering, examining, advising; encouraging,

The Bridge over the Gorge below the Victoria Falls on the Zambesi to carry the Metals of the Cape to Cairo Railway.

The distance from rock to rock is 450 feet. Mr. C. B. Fox, the engineer in charge, had to cross the ravine repeatedly on a chain slung to a wire rope.

[*To face p.* 248.

pointing out faults; guarding against the loss of life and property, which will sooner or later result from any grievous miscalculation on his part. Imagine yourself sitting down to plan out the Forth Bridge. On the one side is your knowledge of strains, thrusts, dead weight, the tenacity of metals, the cost of erection per ton, &c. On the other, the money that will come by the million pounds out of the pockets of shareholders; and the thousands of lives which will be entrusted yearly to the completed structure. A man needs have confidence in himself to plot out such a mass of steel and masonry, for, though he has the help of skilled advisers, his personal fame or failure depends on that bridge fulfilling all its requirements, and coming together "like the parts of a clock." It is indeed a heavy responsibility that rests on the shoulders of the engineer, who may with justice be regarded as the constructional Brain of the Railway.

CHAPTER XVI

THE DEVELOPMENT OF THE LOCOMOTIVE

WHEN your baggage has been safely stowed in the van, and the guard has found you a comfortable seat, you may perhaps have ten minutes or so to spare before the express will draw out for its long journey.

If you are interested in things mechanical it is most probable that you gravitate along the platform to the head of the train, where the great machine in which is concentrated its motive force stands like a swift animal ready to spring forward at the given signal. The driver is peering and prying into the wheels and running gear, a long-nosed oil can in his hand. Every now and then he stretches out his arm and squirts a little of the lubricant into a cap or on to a rod. The stoker meanwhile is consulting the gauges in the cab, or having a look at the furnace. Steam purrs softly from the safety-valves, as a proof that the firing has been well done, and that there is plenty of steam to start the three hundred tons of vehicles which flank the long platform. You look curiously at the many bright fittings which decorate the cab; take mental measure of the size of the driving wheels, the weight of the engine, her probable speed; notice with satisfaction her glossy

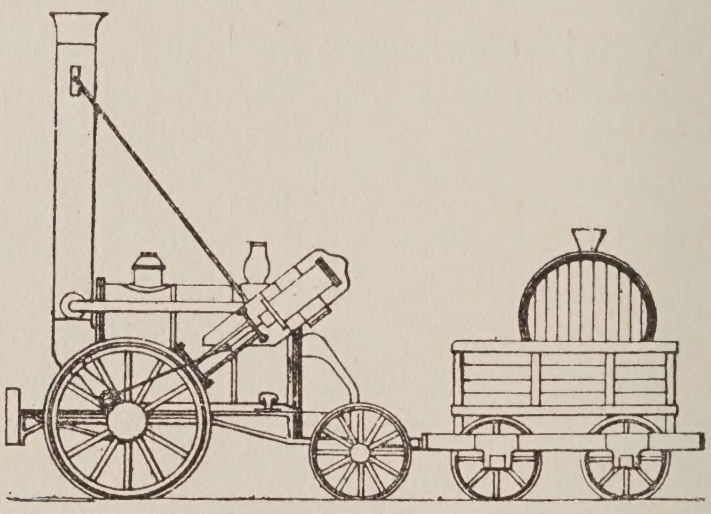
coat, on which the painter has spared no pains; and conclude that "she"—as her attendants always style their charge—is a very fine piece of work indeed. A train without a locomotive is a dull affair, however gorgeous may be the carriages internally. After all, they are only a series of small rooms on wheels; you have seen as beautiful furniture and decoration elsewhere. But when the engine is run on, the whole receives life. It is the absence of the fuss and fume of steam which renders the electric train so uninteresting, as compared with its furnace-driven brother. The motors are small and well out of sight, so that a large part of the romance of railroading is absent on the electric track.

Though the standard gauge of our lines has remained constant since the days of George Stephenson's first engines, a most remarkable change, or rather development, of the vehicles that travel on them has taken place. The small, open cattle-truck pattern of passenger car has been dead and buried for many years. In its place we have a fifty-ton saloon that would have made our ancestors fairly gasp with surprise at its comfort and convenience. Contrast also the 6½-ton locomotive, working at a pressure of 25 lbs. to the square inch, with the mammoth that would tip the beam against a score such locomotives, and could give it eighty miles start in a hundred and a beating, though attached to a fourfold burden.

A fair idea of the advances made in locomotive practice will be derived from a comparison of

Stephenson's "Rocket"—built in 1829, and by no means a mere experiment—with the latest production of English and American workshops.

The "Rocket" weighed, with its tender loaded, 7 tons 9 hundredweight. Its "drivers" were 4 feet 8½ inches in diameter (equal to the standard gauge); its boiler 6 feet long, and 3 feet 4 inches in diameter; its



THE "ROCKET"

cylinders 8-inch bore by 16½-inch stroke; its firebox 2 feet long, 3 feet broad, and 3 feet high. It had twenty-five 3-inch tubes to lead the furnace gases through the boiler to the smoke-box; and a total heating surface of 137¾ square feet. Steam was blown off at 50 lbs.

Now take the Midlands' heaviest engine—112.15 tons; four 7-foot drivers; three cylinders of 26-inch stroke; 1719 square feet of heating surface; a boiler pressure of 195 lbs. Or the Great Eastern Decapod

with 80 tons on the drivers; a tractive power of 14 tons; and 3010 square feet of heating surface.

A typical American mammoth is that built for the heavy grades and loads on the Atchison, Topeka, and Santa Fé. Here are some of the most interesting particulars of one of the largest locomotives in the world :—

Total weight	200 tons
Tractive force	21 „
Boiler	$78\frac{3}{4}$ inches diameter
Firebox, length	108 inches
„ width	78 „
„ depth	$80\frac{1}{4}$ „
Number of tubes	391
Diameter	$2\frac{1}{4}$ inches
Length	20 feet
Total heating surface	4796 square feet = $\frac{1}{9}$ acre
Cylinders, number	4
„ stroke	32 inches
„ diameter	19 „ high pressure
„ „	32 „ low „
Working pressure of boiler	225 lbs.

Generally speaking, the chief object before the designer of engines has been to devise locomotives which shall draw heavier average loads at higher average speeds. To do this he must in the first place increase the size of the boiler, and its strength, while amplifying the furnace and the number of tubes. Secondly, the steam must be employed in the most economical manner; which has led to great improvements in cylinder construction. Thirdly, all parts of the engine must be made of the material found,

after long experiment, to give the most satisfactory results.

The enlargement of boilers, furnaces, and cylinders, has caused the elevation of the frames to a height above the rails which gives modern locomotives a rather top-heavy appearance. Owing to the needs of a restricted loading-gauge, the possible breadth and height of an engine are limited; and as a consequence we see the funnels of the largest English engines become more and more shortened as the boilers increase in diameter. The Great Eastern Decapod—of which an illustration is given—can claim but $7\frac{1}{2}$ inches of funnel height, so that the smoke-stack, once so long and ornate, has shrunk to a mere excrescence. In America, where the designer has at command 2 feet $6\frac{1}{2}$ inches more elevation and 1 foot 11 inches more breadth, he can retain a fairly respectable funnel to finish off his enormous boilers; and also give the engine a breadth which saves it from excessive "dumpiness."

Lest the writer should be accused of a prejudice in favour of all things Anglo-Saxon, he may justly add that French, German, Italian, and Belgian engineers also turn out very fine locomotives. In fact, English designers have been glad to adopt ideas from their neighbours; and at the present moment one of the famous French de Glehn "compounds"—La France—is showing its paces over Great Western metals.

The principles of a locomotive's mechanism are pro-

bably known to the majority of our readers; but for the sake of the minority they will be briefly noticed.

If you put a kettle on a spirit stove, you observe that the flames curl up round the side and waste a great deal of their heat on the air. In order to make the kettle boil faster it is advantageous to surround it and the stove with a screen, which will prevent the flames from being blown aside. Some kettles have concave bottoms, to offer a larger surface to the heated gases of combustion, and others small tubes which pass right up through them. The object of the tubes is to still further increase the heating surface.

Now, in the running of a locomotive, economy is most important. If a driver had to use fuel as lavishly as you do spirit for your kettle, his engine would soon be dismissed from service.

In order to get good value for coal burnt the furnace is entirely surrounded with water, except, of course, at the bottom. The earliest engines had merely a single big flue running straight through the boiler below the centre line, the furnace being in the after-part. This was found to be so wasteful and ineffective a method that George Stephenson in his "Experiment," built in 1826, fitted a double tube between the furnace and funnel; in the "Rocket," 25. The effect was speedily shown by a remarkable increase of speed; for the Rocket at the Rainhill trials attained 29 miles an hour, and kept it up. Since then the number of fire-tubes in a locomotive has steadily grown.

The American Decapod, of which some dimen-

sions are given above, has 391 tubes; and as each is 20 feet long the total length of these steel pipes is, by a curious coincidence, exactly one and a half miles. The reason for multiplying the tubes while diminishing their diameter will be evident after a little calculation. Let us suppose that we have a cylinder ten feet long, and exactly one foot in external diameter. The surface of this tube is $3\frac{1}{7} \times 10 = 31\frac{3}{7}$ square feet. Next, take two cylinders of the same length but 6 inches in diameter. Their combined surface is evidently equal to that of the larger cylinder, though their sectional area is but one half. Therefore if they were all three stopped at one end and stood upright and the two smaller tubes inserted into the large one, they would be found to displace just half of the water that it could hold. This means that two six-inch tubes passed through a boiler will give as much heating surface as a single one-foot tube, but will occupy only half its room. Similarly, by employing 3-inch tubes you will get the same amount of heating surface for one quarter of the displacement of water, and so on. So the boiler-maker uses many rows of small tubes packed close together, with the result that the comparatively trifling amount of water among them is boiled very quickly. The fire and hot gases travel along the tubes, transmitting their heat to the water as they go; but if there were no artificial means to aid their progress the fire would burn very dully, and the steam would fall. It was Stephenson who

first thought of sending the exhaust steam up the funnel so as to blow all the air out of it and produce a vacuum, which could only be filled by more air rushing in through the one possible path—viz., the furnace and tubes. The beauty of this arrangement is that the faster the engine works the stronger is the blast and the fiercer the fire. When the steam is shut off the suction ceases, and the heat becomes less intense. This is just the state of things required in practice.

The most effective portion of the heating surface is of course that round the fire-box. In engines required to do very heavy work, it is of no use to merely increase the number of tubes, since a given weight of coal can produce but a certain amount of heat. The fire-box itself must be enlarged, so as to have a more extensive grate-area on which a proportionate quantity of coal can be burned economically. This practice is followed much more largely in the United States than in Great Britain. Our strongest engines rarely have a grate-area exceeding 25 square feet; whereas on the other side of the Atlantic the figures rise to 90 square feet; 45 to 50 being quite common.

These large furnaces are usually much longer than they are wide, but the largest of all wider than they are long. The latter type is the invention of Mr. John E. Wootten, the Superintendent of Motive Power of the Philadelphia and Reading Railway Company, from whom they take their name. Some are ten feet wide, and the rear part of the boiler has to expand

into a saddle shape for their accommodation, the driver's cab being put forward of the fire-box, halfway between the two extremities of the boiler. It has been found not only possible, but also profitable, to burn refuse or unmarketable coal in these fire-boxes; while with good coal they will give fine results. Mr. Samuel J. Vauclain, the manager of the Baldwin Works, Philadelphia, says of an engine fitted with this type of furnace: "Many of the leading mechanics of Europe were excited over its performance on one of our seashore lines. This engine covered the fifty-five miles every day, throughout the season, in less than fifty minutes; many days in forty-five, and seldom over forty-eight. Those of you who sit at the throttle (*i.e.* the drivers) know what this means much better than those who do their railroading riding in a Pullman car, and can appreciate it accordingly. Larger and more powerful engines of this class have been made, but none have a more satisfactory record." A large number of Wootten fire-box engines have been sent from America to Japan to burn the peculiar quality of coal found there, which speedily clogs a small fire-box.

The question of liquid fuel for locomotives and steamships has been much before the public of late years. In Russia, the Southern States, and Burmah, where petroleum is much more plentiful than coal, many engines are driven with the crude, unrefined oil. The Great Eastern Railway in England has also adopted liquid fuel on some of its express

engines. Of one of these Mr. C. E. Stretton writes :[1] "Beyond the addition of an oil-tank on the tender, and a few pipes leading to the liquid fuel injectors below the fire-hole door, there is nothing in its outward appearance to distinguish it from a coal-burning locomotive, to which it can be converted at any moment, there being no alteration in the construction of the fire-box. A special feature of the injector is an outer ring through which jets of steam pass, these jets impinging at the nozzle on the liquid fuel induced through a central cone, and breaking the fuel up into a very finely divided spray, which ignites immediately. There is a passage in the injector through which air also is induced, and as the emission of steam, liquid, and air can be adjusted independently of each other, combustion is regulated to a nicety, and the slightest smoke avoided. The fire is lit up with coal in the usual way, and a bed of incandescent fuel, or chalk, or broken bricks kept up, the weight of coal used in conjunction with the liquid fuel being about one-third of the total fuel consumed. The saving of labour to the fireman is, of course, very great; whilst the incandescent base enables the engine to lie practically inert for hours if required, yet ready to start into action directly the injector is worked." Experiments have proved that 17 lbs. of liquid fuel will raise as much steam as 35 lbs. of coal, under favourable conditions. It is therefore probable that in the south of England, and in districts where petroleum is easily obtain-

[1] "The Development of the Locomotive," by Clement E. Stretton.

able, the oil-burner will largely supplant the "black diamond."

We may now pass to a consideration of the cylinders, which transform the steam into motive-power. In this part of a locomotive's mechanism great improvements have been made, though, owing to want of space, engines cannot utilise all the steam so fully on a locomotive as on a ship. The loud "puff" with which steam is ejected from the funnel denotes that it leaves the cylinders in an only partly expanded state; that is, a portion of its energy is wasted. Locomotives are therefore often "compounded," a term which signifies the passing of the exhaust steam from the high-pressure cylinders to low-pressure cylinders of larger diameter, where its expansion proceeds for another stage. The system was first introduced by Mr. A. Mallet, in 1876, in France, and since then has been largely adopted in that country and America, and to a smaller extent in Germany and England. Some compounded engines have two cylinders only —one high and one low-pressure; others three—two high and one low-pressure; and others, probably the most effective, two of each. Messrs. Vauclain, in America, and De Glehn, in France, have produced very powerful "compounds," which show a considerable economy, especially on long inclines. Mr. Vauclain thus states the case for the compound: "The principal object in compounding locomotives is to effect fuel economy, and this is obtained—

"1. By the consumption of a smaller quantity of

steam in the cylinders than is necessary for a single-expansion locomotive doing the same work.

"2. The amount of water evaporated in doing the same work being less in the compound, a slower rate of combustion, combined with a mild exhaust, produces a higher efficiency from the coal burned.

"One of the obvious advantages of the compound system is that, owing to the better utilisation of the steam, less demand is made upon the boiler, which enables sufficient steam-pressure to be maintained with the mild exhaust, due to the low tension of the steam when exhausted from the cylinders. This milder exhaust does not tear the fire nor carry unconsumed fuel through the flues into the smoke-box, and thence out of the smoke-stack; but is sufficient to maintain the necessary rate of combustion in the fire-box with a decreased velocity of the products of combustion through the flues. The heating surfaces of a boiler absorb heat units from the fire and deliver them to the water at a certain rate. If the rate at which the product of combustion are carried away exceeds the capacity of the heating surfaces to absorb and deliver the heat to the water in the boiler, there is a continual waste that can be overcome only by reducing the velocity of the products of combustion passing through the tubes. This is effected by the compound principle. It gives, therefore, not only the economy due to a smaller consumption of water for the same work, but the additional economy due to slower combustion. It

is obvious that these two sources of economy are interdependent."

The writer hopes that this explanation will not appear too abstruse. Summed up, it means that the steam from the low-pressure cylinders give a gentle but sufficient draught, and that a certain amount of power is exacted at the cost of less fuel than is possible with a "simple." In practice, railway managers find that the compound engine, other things being equal, will save 10 to 15 per cent. of the fuel used by a "simple" in passenger work, 15 to 20 per cent. in goods traffic, and as much as 40 per cent. where heavy grades have to be negotiated. On a line which has a yearly coal bill of several hundred thousand pounds, this saving is of great importance to the shareholders.

The low-pressure cylinders of a compound engine can be worked with high-pressure steam for starting a train on exceptionally steep inclines. To prevent an undue strain on the low-pressure piston-rods, an intercepting valve is fitted which prevents the pressure from ever exceeding a certain figure.

The size of driving-wheels for express engines has of late years been somewhat diminished, owing to the heavier loads put behind an engine. "Single drivers" are now seldom built for express traffic, and then with wheels only 7 feet 6 inches in diameter. In the old days of the broad gauge, 8½, 9, and even 10-foot wheels were employed; but speed was gained at such a loss in power that 8 feet became the limit; and this has

dropped to about 7 feet. On looking through a tabulated list of the express engines used in various countries you will rarely find a wheel of a larger diameter than 80 inches. But wheels of this size are generally coupled two or even three on a side, giving great tractive power to the engine.[1] That very high speeds can be attained by comparatively small "drivers" is evident from the fact that the fastest runs are done in the United States, where an 80-inch wheel is practically unknown.

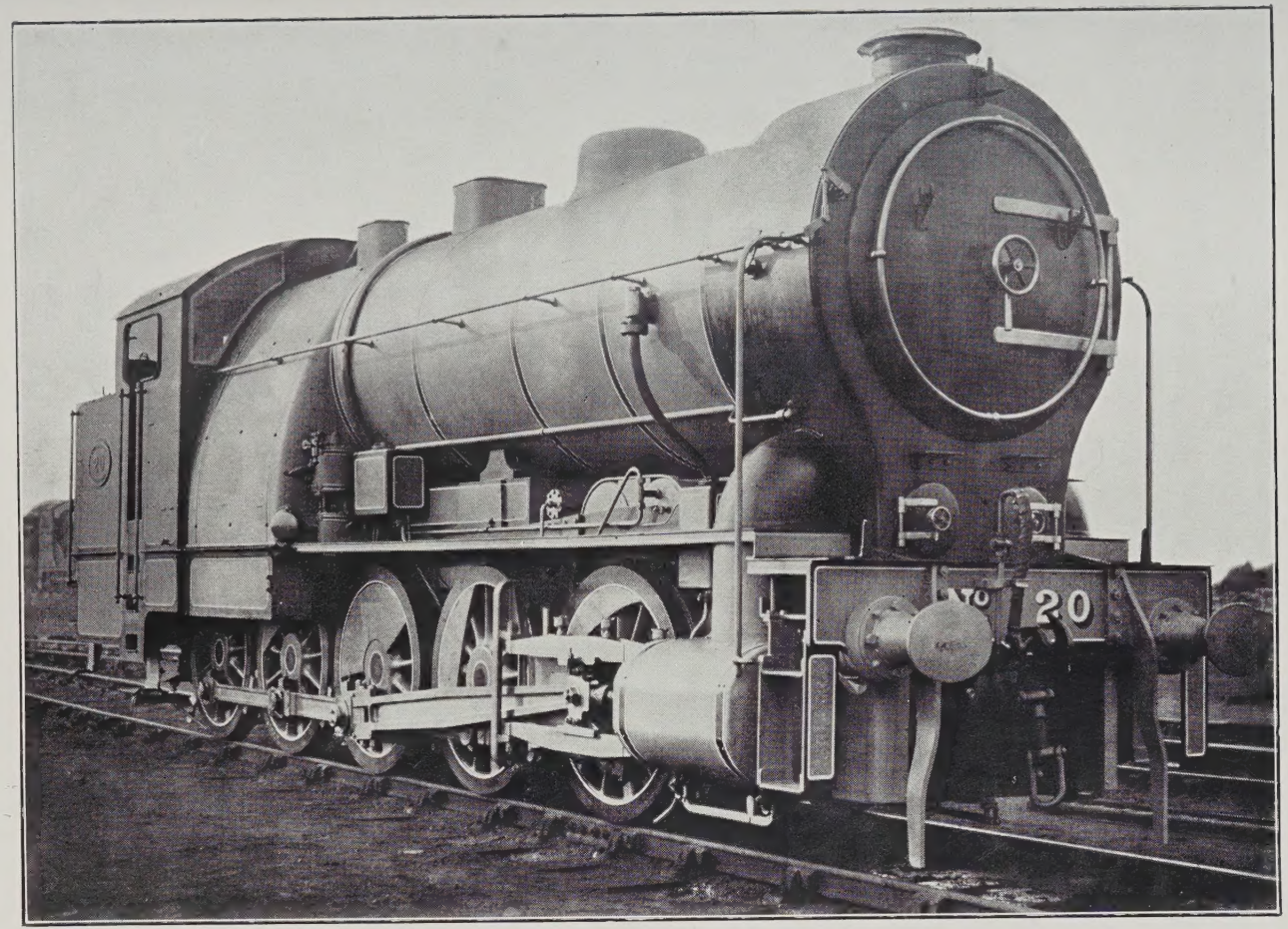
For goods traffic it is usual in England to put the total engine weight on half-a-dozen wheels 4 to $4\frac{1}{2}$ feet in diameter. In America a leading 4-wheeled bogie is kept, or at least a 2-wheeled truck; and the rest of the weight is suspended on three, four, or five pairs of coupled drivers, which distinguish the engine as a "Mogul," "Consolidation," or "Decapod" respectively. Of the last type we have only one instance in England, and it is not a "thoroughbred," since its total weight rests on the drivers. Thanks to the courtesy of Mr. James Holden, the designer, an account of this mammoth can be appended.

For some years past the Great Eastern Railway Co. has had to struggle hard with the problem of carrying to and from London the vast host of passengers who live in the eastern suburbs, and have their business in the metropolis. Liverpool Street Station, the London terminus, was practically rebuilt in the

[1] The tractive force of a locomotive is usually reckoned at one-fifth of the total weight on the driving-wheels.

'nineties, and at present holds the proud position of being the largest station in the world, with its eighteen platforms and twenty roads. Yet even so the cry has been for more accommodation, and the Company had to take its choice between three courses—to build a "tube" line under the existing line for local services, to electrify the existing system, or to employ engines of greater power and acceleration. Mr. James Holden, the G.E.R. Chief Locomotive Superintendent, gave it as his opinion that, since the efficiency of each course could be proved only by experiment, the third was worthy of the first trial, because the building of an engine could be done for a few thousand pounds, whereas to convert the motive power or to build a "tube" would absorb millions of capital.

On being granted permission, he proceeded to design a locomotive on lines that at once introduced fresh principles into English practice, and made this the most powerful engine in the British Isles. The whole of its weight was to be available for tractive purposes. There would be no bogie or trailing wheels; but on each side five drivers coupled together by connecting bars, and actuated by three cylinders — two outside and one inside the frames. These, all of 24-inch stroke and 18½-inch bore, are fed with high-pressure steam from a huge boiler 22 feet 3¾ inches long and 5 feet 4¼ inches in external diameter. The fire-box, which is of the Wootten type, and has 42 square feet of grate area, is connected with the smoke-box by 395 flues, giving a total heating surface of



The Most Powerful English Locomotive.

A "Decapod" built for the Great Eastern Railway suburban traffic. It weighs 80 tons and can, with a load of 350 tons behind, attain a speed of 30 miles an hour in 30 seconds. The five driving wheels on each side are all coupled together.

[*To face p.* 264.

3010 square feet—that of the fire-box included. The boiler works at 200 lbs. pressure, and has six safety-valves. Its centre line lies so high above the rails that the funnel is very squat, being little more than a ring $7\frac{1}{2}$ inches high.

The wheels are all $4\frac{1}{2}$ feet in diameter; and the central pair, which the cylinders drive directly, have no flanges, so that the long wheel-base of the engine may not hamper its movement round curves. As the engine scales, when fully loaded, no less than 80 tons, it has in dry weather a maximum tractive power of 16 tons. Its 2500 horse-power were considered by its designer to be sufficient to accelerate a load of 315 tons (18 four-wheeled carriages) from rest to a pace of 30 miles an hour in 30 seconds.

A trial run was made over a length of track near Chadwell Heath, where, for 450 yards, a series of electrical contacts were laid by the road in connection with a registering apparatus in a cabin close at hand. A clock marked off half-seconds on a moving strip of paper, and an electrically-driven pencil also recorded the periods taken by the engine to pass from one contact to the next. As the contacts had been arranged at the points which should theoretically be reached at the end of each half-second, it was easy to see, by comparing the contact and second marks on the tapes, whether the engine was maintaining the full acceleration.

On the first trial the boiler "primed," that is, it passed water-charged steam to the cylinders, but on

a second occasion, after certain alterations had been made, it fulfilled its requirements and realised all the hopes of Mr. Holden. Unfortunately for the Decapod, the bridges over which it had to pass were built in days when such ponderous locomotives were unknown, and, as a consequence, the ten-driver has been temporarily withdrawn from regular passenger traffic. The Company has decided to alter its existing engines so that they may pull 17 coaches with the same ease as they now handle 15, and to remain satisfied with an acceleration of 20 miles in half a minute.

As will be seen from our illustration, the huge Decapod, with its squat chimney and high, broad shoulders, looks the ideal of power. Even among the American giants it would take an honourable place as regards both strength and dimensions.

The loads that these heavy engines can pull are extraordinary. On the North-Eastern Railway a single engine has hauled a train of 81 loaded trucks and a van—the whole one-third mile long—up a gradient of 1 in 108. In Germany 900 to 1100 tons is quite a usual total to put behind a goods locomotive; and in America, where mineral and grain is moved in bulk, 2000 tons is considered fairly good practice, though nearly 4000 tons are sometimes harnessed behind an engine where gradients and curves are easy. Even such lengthy strings of vehicles make good time, a speed of 15 to 30 miles an hour being kept up over long stretches. To avoid the necessity for frequent stops to take in water, some American tenders

have a capacity of 8000 gallons, carried in tanks surrounding a space in which upwards of 10 tons of coal can be stored.

Among the many fittings with which a modern locomotive is provided, the "injector" deserves special notice. The pump is now little used for feeding the boiler with water; or, if employed, it is supplemented by an injector. This contrivance appears at first sight to work on paradoxical principles, as it causes steam to force water into a vessel where the pressure may be even greater than that of the steam used. There are no moving parts, as in a pump. The action of an injector is based on the fact that the velocity of steam escaping from the boiler at a given pressure is very much greater than that of water under the same condition. Steam is led from the boiler through a pipe terminating in a fine nozzle, which projects downwards into a pipe also connected with the boiler, but entering it below the water level. Between the nozzle and the boiler is placed a valve opening towards the boiler, and preventing any escape of water outwards. As soon as steam is turned on it rushes from the nozzle with tremendous velocity, and by causing a vacuum in the pipe surrounding the nozzle sucks water from a tank through a third pipe. The velocity of the steam is gradually imparted to the water, which impinges on the valve and drives it open, because its *momentum* is greater than the pressure on the boiler side of the valve.

CHAPTER XVII

THE CRADLE OF A LOCOMOTIVE

IN England it is usual for each important railway to have its own locomotive factory, to which is often added a series of workshops for the construction of carriages, trucks, and the hundred and one appliances which are commonly used in the maintenance of a line and its rolling-stock. At Swindon, Crewe, Derby, Doncaster, Gateshead, Cowlairs, Ashford, Nine Elms, Horwich, we find thousands of men busily engaged on the conversion of metal into those engines of which the Englishman is so proud, on account of their shapeliness, finish, and durability.

A visit to one of these great factories is indeed an important day in the visitor's life, and a noteworthy addition to his general education, especially if he be a person hitherto unacquainted with the antecedents of the steam horse that carries him so swiftly about the country. His interest is at once aroused, even before he enters the roar of the shops, by learning how quickly they have converted acres of green fields into the scene where so many hundreds of skilled workmen earn their daily bread. Take, for example, the case of Crewe—in 1841 a village of 203 inhabitants. The locomotive works were

established two years later; in 1851 the population had risen to 4571; and ever since it has increased by leaps and bounds, keeping pace with the extension of the factories, till at the present day no less than 35,000 people are gathered round the great engineering establishment, which employs upwards of 7000 hands and covers a quarter of a square mile.

Or, again, turn to Swindon, on the Great Western, and its increase from 2,459 to 45,000 souls in half a century; or to Stratford, where the works are the focus of a small town. In fact, the same story can be told of all the places mentioned above as the headquarters of a railway's creative department.

On entering the works the stranger is almost appalled by the noise and motion that at once envelops him. Standing about, tended by little gangs of men, are strange machines of which he had never dreamed, and others of which he has read, maybe, but seen only in their photographic presentments. As he passes from shop to shop he sees sights that will impress themselves on his memory for many a long year to come; though they succeed one another so fast that only after the lapse of a little time, when he has had a chance to rally his overtaxed brain, can he clearly separate them. In addition to his admiration for the individual processes by which metal is tortured, battered, pinched, trimmed, and shaped, he will be left with a general increase of respect for the men who designed and the men who operate the many forms of machinery employed by the locomotive builder.

In order to economise time and labour, a railway works is subdivided into several departments, each having its separate building, and being connected by rails to the rest. There is the casting shop, with its huge crucibles and queer-looking moulds, which convert molten metal into the rough likeness of wheels, cylinders, and other objects too numerous to mention; the forging shop, where huge steam hammers pound away at a mass of white-hot steel until it has been broadened or lengthened into a shape at which the spectator could hardly have guessed when the ingot left the furnace; the rolling shop, which flattens out glowing lumps into thin plates of steel or iron, as easily as your cook expands a pound of pastry into a pie-crust, and huge scissors trim the plates like so much paper, or cut lengths off a thick steel bar as if it were soft German sausage. Before you have fully recovered from this heroic handling of metal by metal you are in the clangour of the boiler shop, where all the demons of noise appear to be rioting madly together, and you soon trace the uproar to dozens of hammers smiting the heads of red-hot rivets. Your guide smiles, and points to the hydraulic riveter, which, in a quiet manner that contrasts with the din around, is closing up rivets at the bidding of a man who works a small lever. On all sides stand boilers in various stages of completion; some only a mere beginning; others externally complete, but minus the hundreds of tubes that

will soon fill their strong stomachs; others ready for transportation to the construction shop, where they will first make the acquaintance of the other weighty portions that are items in the sum of a finished locomotive.

To the layman, the turning shop is perhaps the most interesting, because it contains a number of extraordinary tools, beautifully adapted to the work they have to perform. Our illustrations include two views of this department of the Horwich Locomotive Works, where the rolling-stock of the Lancashire and Yorkshire Railway is made. The one (p. 284) shows a pair of 7-foot driving wheels being turned on a large lathe, after the rims have been driven on the wheel centres, which in turn have been forced by hydraulic presses on to their axle. On the right-hand side are seen two pairs still tyreless. The "facing-plates" of the lathe slowly revolve, carrying the wheels with them, while a tool is fed up to its work by an attendant, and moved horizontally by an ingenious automatic arrangement of cogs and worm-gear. At every revolution the wheel has a part of its diameter removed, perhaps only a hundredth of an inch, until the whole "tread" has been reduced by the adamantine tool to perfect circularity and smoothness. In other parts of the shop cylinders are being bored out, and all their flat surfaces scraped perfectly true by steam planes, which travel to and fro with monotonous regularity. Here crank-pins receive their proper shape; there a connecting-rod

is having its ends, pin-holes, and bosses trued—for the uttermost exactness is a leading feature of every part of a locomotive. You will probably stop a few minutes to watch the operation of a turret-head machine, as it bores the inside of a cylinder and simultaneously shapes the outside too; and the capstan lathe, which bristles with curious tools, any one of which the man in charge can bring into action by a simple movement.

In the erecting shop the products of the forgers, the boiler-makers, the turners, the planers, and the finishers, are all brought together. Up and down the bays of the great shed run overhead travelling cranes, which toy even with the weight of an entire locomotive. Could you but stay and watch for a few days you would see how the frames are set up; the cylinders attached; the boiler lowered into position, fixed, lagged, and connected to the many steam and water pipes that enter it; the wheels rolled under the frame; the multitudinous rods slipped on to their pins; the funnel set up; the cab filled with its fittings; and the whole combination tested before it is forwarded to the painting shop to receive its shining coat of green or blue or chocolate, relieved with neat lines, and shown up to advantage by surfaces of glistening black.

Even when your eyes have had their fill of locomotives there still remain the waggon and carriage shops, and all their wonderful wood-working machinery; and the saw mills; and the pattern-makers' shop; and the

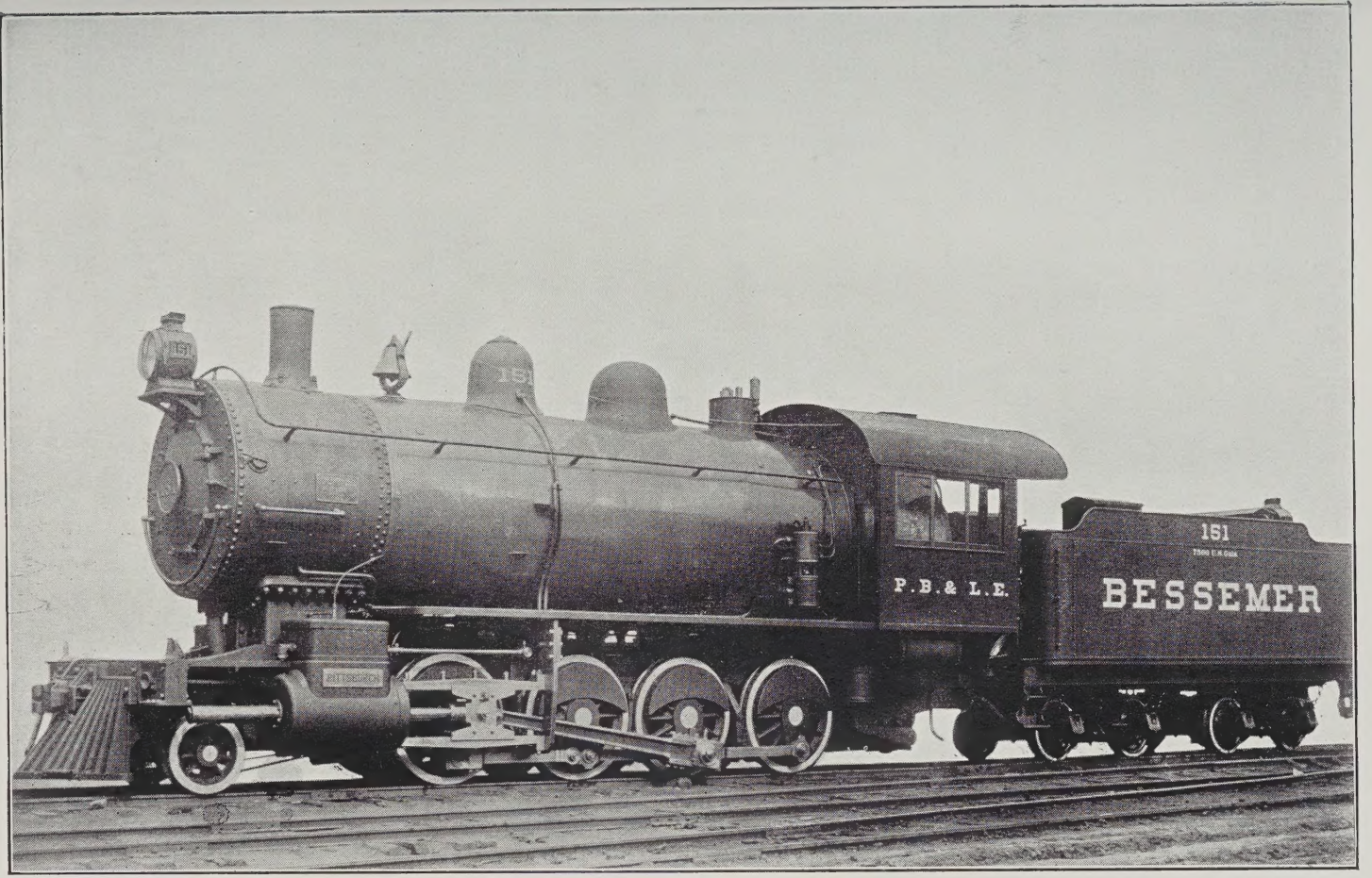


Photo by] [*F. Moore*

One of the Heaviest Locomotives in the World.

Made at the Pittsburg works for the Pittsburg and Lake Erie freight traffic. Engine and tender together weigh 200 tons. Just forward of the driver's cab is seen the steam air-pump for the Westinghouse brake.

[*To face p.* 272.

power house; and the offices where delicate tracings are made of every design used on the premises. You can no more get to the bottom of such works as those at Swindon or Crewe in a single day's "walk round" than you can do justice to the Royal Academy's pictures in a half-hour scamper through the galleries.

From generalisations we will descend to particulars, and focus our attention on an engineering establishment which is not so well known in England as the works already mentioned, though it holds first place in the world as a factory of locomotives, as measured by its output. The Baldwin Locomotive Works, Philadelphia, supply not only most of the large railway systems of the United States, but also Russia, Japan, Africa, South America, and to a smaller extent France, India, and England, with engines built to suit the requirements of any designer. They are, in truth, a factory, from which completed engines are turned out at the rate of over six for each working day. The greatest output was reached in 1903, when 2022 were built, exclusive of extra repair parts equal to another 250 locomotives. The works employ 15,800 men, who work 10 hours a day, shift relieving shift, so that, Sundays excepted, there is no cessation whatever. The buildings, which number 39, cover 17 acres, and have 37 acres of floor space. Eleven thousand horse-power is absorbed by the machinery, representing a yearly coal consumption of 100,000 tons.

The first locomotive turned out by the firm was

put together by one Matthias Baldwin, in 1832. Baldwin, a jeweller by trade, received that year an order to build a model locomotive for the Philadelphia Museum. His work was so successful that he then was asked to construct a full-sized machine for the Philadelphia, Germanstown, and Norristown Railroad Company, whose short line of 6 miles was operated by horse-power. The "Old Ironsides," as this was called, is the American counterpart of the English "Rocket." It was four-wheeled, and had 54-inch drivers, cylinders $9\frac{1}{2} \times 18$ inches, and a wooden frame. The boiler contained 73 copper tubes, each 7 feet long. Great difficulty was encountered owing to the lack of proper tools. For boring the cylinders a chisel fixed in a block of wood, and turned by hand, had to suffice. The wheels were made with wooden spokes, wrought-iron tyres, and cast-iron hubs. Blacksmiths able to weld a bar of iron exceeding $1\frac{1}{4}$ inches in thickness were not to be found. Mr. Baldwin had to do much of the work with his own hands, and to educate the workmen who assisted him, besides improvising tools for the various processes. Yet, in spite of all these difficulties, the "Old Ironsides" was completed in ten months, "and with its usual train of passenger coaches attached, attained a speed of 30 miles an hour. The new machine was regarded rather as a curiosity and a bait to allure travel than as a practical, everyday servant. So great were the wonder and curiosity which attached to such a prodigy, that people flocked

to see the marvel, and eagerly bought the privilege of riding after the strange monster."

After this Mr. Baldwin went into regular business as a locomotive builder, and started an undertaking which has gradually swelled to its present colossal size. In February 1902 the 20,000th finished engine, a compound ten-wheeled, left the works.

Let us now follow an American locomotive through the course of its construction, which is conveniently divided into four divisions—the making of the boiler; the making of the cylinders; the making of the wheel frames; and the final assembling or erecting. For the guidance of the English reader it should be remarked that on American engines the flat, spacious "bedplate," or platform, of the British locomotives, to which the cylinders are secured, is replaced by a comparatively light frame, the cylinders and their massive saddles being fixed to the boiler direct, and designed to act as a base for other attachments, such as the cow-catcher.

The Boiler.—In modern American boilers steel is used throughout, except when designed for export, in which case the fire-box is often of copper. The steel is received at the works, in sheets of various sizes and thicknesses, from the manufacturers who make a specialty of plate-rolling. In America specialisation has gone so far that no locomotive factory attempts to manufacture all its material, finding it cheaper to get a large part of it ready prepared.

Some of the steel sheets are 20 feet long and

from $\frac{3}{4}$ to $\frac{7}{8}$ inch thick. They are moved about the workshops by means of overhead travelling cranes, which are the more easily worked on account of the absence of belting in shops where electric motors operate most of the tools.

The plates have first to be prepared for punching and drilling. They are laid on a table and the centres marked from standard gauges. If a flanged edge is required, the holes are not marked until the flange has been formed. When the centres have been determined, the sheet is introduced to an electrically-driven punch. Above the machine is a crane from which the plate is suspended by means of chains. The punch has a projection on its under side, and as soon as this projection catches in a centre-mark the punch is started and soon bites out a clean round hole.

Flanging—*i.e.* turning up the edge of—a plate is done on hydraulic presses, which exert a force of 365 tons. The plate is heated in a large furnace, and placed on a suitable "form," clamped firmly to the table on the end of the ram. This rises and forces the plate into a mould, which turns the edges over to the shape of the form. Tube-sheets, dome rings, and many other parts can be thus fashioned much more rapidly and accurately than is possible in hand work.

The plates are now sent back to the boiler shop for assembling. Their edges are planed off by special machines. The plates for the boiler barrel (the circular portion) are fed into a bending machine, which consists of three rolls turned by electricity.

The two lower rolls are on the same plane, but the third is adjustable as to its height, its position being controlled by large screws, one at each end. By altering its position the plate can be bent to any required radius.

We will suppose that all the plates are flanged, bent, and drilled. They have now to be put together by the agency of hydraulic power. The machine used for riveting has a horseshoe shape, the two horns being parallel and close together. At their extremities, on the inside, they carry dies, the one fixed, the other moved by tremendous water pressure. The boiler barrel, roughly bolted together, is raised end up and lowered with the plates between the two jaws of the riveter, which quietly closes the rivets in succession. A 25-ton travelling crane now hoists the several parts of the boiler to the upper floor of the shop, where the rear half is placed upside down, and the inner shell of the fire-box is fixed in position by means of nuts and bolts. For some portions hand riveting is necessary, as an hydraulic riveter cannot be introduced into very confined spaces. The fire-box being finished, the boiler is turned up again and the steam dome assembled and secured; and all seams are "caulked" at the joints with a tool having a rounded edge, after the forward end-plate has been fixed. The workmen now add the smoke-box extension, which is joined to the front boiler-ring by an external ring, to give a smooth finish on the outside.

We will leave the boiler to be conveyed to the erecting shop while we visit another section of the works where the cylinders are being made. For these cast iron is always used. In the foundry are three cupolas or crucibles, having each a capacity of 50 tons. The cupola is a stack built of metal plates, lined with fire-brick to withstand the terrific heat. Trucks of pig iron and scrap iron are hoisted up to the mouth, into which the materials are shot on the top of a thick bed of coke. Then more coke is put in, and another layer of metal, and the process is repeated until the cupola is full to the proper level. An air-blast, produced by a large blower, is now forced into the cupola through two openings about 5 feet from the bottom, and very soon the metal has all been reduced to a liquid form fit for casting. The tap is a small opening closed by a clay plug, and discharging into a spout from which the metal runs into ladles.

The moulders have meanwhile prepared the cylinder moulds, which are filled from a smaller ladle in two "goes," as a schoolboy would say. When the pouring is finished, the moulds are allowed to stand about twelve hours before the casting is removed, and after removal the latter remains untouched for a day longer. Then the outside is cleaned, and all jagged projections are chopped off preparatory to forwarding the casting to the turning shop.

The engine we have under consideration is a "compound," and the steam is admitted to the

cylinders through piston valves. So that each casting has three circular passages, with parallel axes, to be bored out. First of all the end surfaces are well planed down, and the whole is placed on a table so that the final outline of all the passages may be scribed on the ends. Then it is ready for the boring machine, which clears out the two cylinders and the steam chest simultaneously with three boring bars, which are adjustable so as to fit cylinders of different sizes. The bars can be rotated independently by toothed clutches. Each has a slot running almost its entire length, and in the centre of the bar is located a screw revolved by means of separate gearing. The tools are carried on collars, which slip over the bars, and have pieces projecting inwards through the slots and taking hold of the screws, so that as the latter rotate the tools are gradually shifted along the bars.

Before placing the cylinder on the machine, the workmen so adjust the bars that their centres are exactly the distance apart of the centres of the finished cylinders. The bed to carry the casting is slid along, leaving the bars unsupported at their outer ends. The casting is then placed on the bed and fixed in position, after which the bed slides back into place for the final adjustment of the bars to their true centre lines.

As they come from the foundry, the cylinders are about $\frac{3}{4}$-inch less in diameter than they are to be when the boring process has been completed. To remove this surplusage the tools must be sent through them

three or four times, a sharp lookout being maintained to see that the clearing is not carried too far.

The cylinder ends are now clamped in place, and holes are drilled through the cylinder flanges to match those already in the ends. A steel bush, or lining, is next driven into the steam-chest with the proper apertures for the steam already cut. The piston valve gradually wears this lining away, and it can easily be replaced. This process finished, and all flat surfaces carefully planed down, the cylinder is forwarded to the erecting shop.

Wheels, &c.—At the Baldwin works cast steel is used for driving-wheel centres on fast passenger engines (the centre includes the hub, spokes, and inner part of the tyre), and cast iron or cast steel for freight work. All steel castings are purchased from other firms.

The first operation is to prepare the wheels for forcing them on the axles. They are laid down on special machines with rotating tables, and the hubs are faced and then bored out to size with great accuracy. A keyway is slotted in each hub. The axles, of hammered steel, are in the meantime turned and finished in lathes, the accuracy of their measurements being constantly proved by delicate gauges. Then a keyway to match that in the wheel-centres is cut at each end of the axle, the one being at right angles to the other on the circumference. In order to ensure a tight fit, the hub is drilled out to a diameter less by $\frac{.3}{1000}$ of an inch per inch than that of the axle end. The axle is now hung between the uprights of

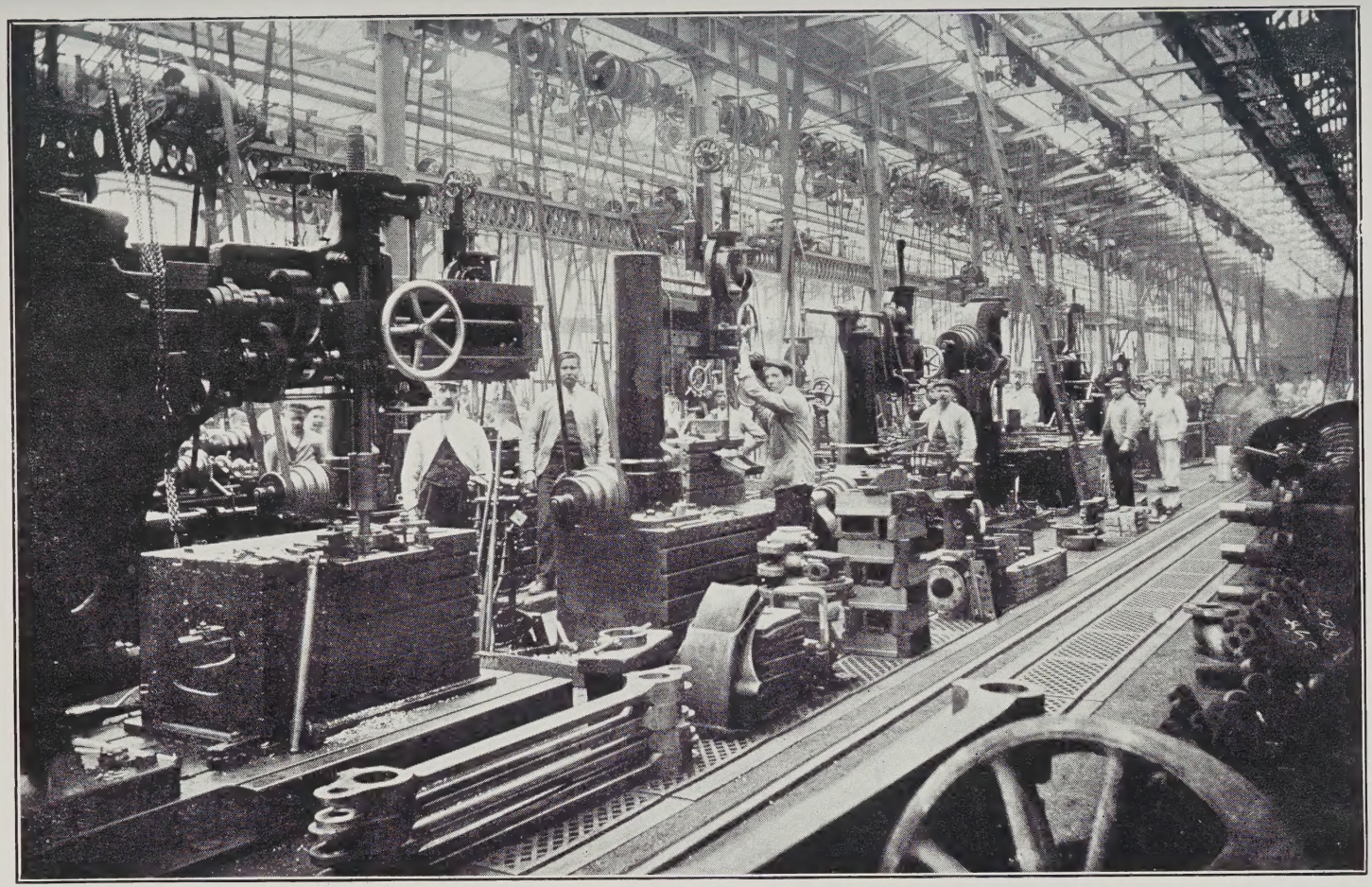


Photo by] *F. Moore*

The Planing and Finishing Shop, Horwich Locomotive Works.

Observe the pile of connecting rods in the left foreground. This is one of the best equipped shops in England.

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a hydraulic press, and one of the wheels set up in front of it, the two being so placed that the keyways exactly match. A man smears the end of the axle and the interior of the hub with a mixture of blacklead and oil, to act as a lubricant. Then the space between the other end of the axle and the ram is filled up with metal blocks, and pressure applied at the rate of 10 tons to every inch of axle diameter. After one wheel is on, the axle is reversed and the other wheel attached in like manner. Finally, wedges are driven into the keyways to prevent any movement of the wheel round its axle.

The lathe now comes into use again. The axle is mounted on the centres, and the wheels have their rims turned perfectly true to gauge, in readiness for the tyres, which, when expanded by heat, will just slip over the rims. As they cool they bind themselves on with enormous force.

All crank pins are next turned and hydraulically forced into their holes; the connecting rods are finished off, and all their frictional surfaces lined with steel bushings. The frames have been forged, planed, and drilled, by most ingenious machinery. The springs have been built up of cast steel *laminæ*. The steam dome cover has been beaten out of a ductile iron plate. The tender tanks are ready; also the trucks for the smaller wheels. And all brass fittings and the air-brake apparatus are complete. So we can follow them to the last scene, which is enacted in

The Erecting Shop.—This, at the Baldwin Locomotive Works, is 160 feet wide by 337 feet long, the area being divided by rows of columns into three bays, each spanned by two Seller's electric travelling cranes of 50 and 100 tons capacity respectively.

Sometimes the boiler is first set up, sometimes the frames. In this particular case we will suppose that the former has the precedence.

The boiler, then, we picture as supported on strong jacks fore and aft. Men now scrape the upper circular surfaces of the cylinder saddles to a true fit against the under side of the smoke-box. The cylinders are then bolted on. In the meantime the tube-fitters have been busily inserting the many iron tubes, for which holes had already been made in the fire-box and forward end plates. These are reamed out until the tube passes easily through them. At the smoke-box end a copper ferrule is slipped over the tube, so that when the latter is expanded it may have a semi-elastic cushion between it and the tube-sheet and form an absolutely watertight joint. The expanding tool is applied on both sides the sheet, bulging out the tube so that it cannot be forced either way.

Here comes a crane with the frames, which are described as the backbone of an engine. They must be fixed on a dead true line, and to effect this a string is run from the centre of the low-pressure cylinder exactly through its axis and secured to a standard placed beside the rear end of the frame. A heavy cross-plate, or yoke, is now bolted to the boiler and

to the frames, to hold them rigid and also form a seat for the bars which guide the piston-rods.

The next step is to get the driving-wheels in place. They are standing ready on a vacant track near their engine, properly spaced. A crane picks up the boiler and all its attachments, swings it over the wheels, and slowly lowers it so that the journals in the frames settle truly down on to the axles. Assuming that the boiler fittings are all fixed, the water test can be applied. The blow-off cock is connected to a high-pressure hydraulic main, and water forced in until the gauge shows a stress one-third greater than will be used in actual running. Men dodge about with their caulking tools, and wherever there is a sign of leakage they hammer at the seam until it is perfectly tight. The boiler is now emptied for the steam test —220 lbs. per square inch—which is applied to the steam passages and cylinders as well. These tests are very carefully carried out, in order to prove that the boiler and all its fittings are perfectly sound before the engine leaves the shop.

Preparations follow to run the engine before setting it down on the rails. The wheels are all "lined up," that is, adjusted to exactly the position they should occupy with reference to the centre lines of the cylinders. The connecting-rods are set, the link reversing gear assembled, and the valves set to show the amount of "lead" required, and the eccentrics are keyed to the main axle. Simultaneously the laggers encircle the boiler and the back of the furnace with slabs of

magnesia, to enable the boiler to retain its heat better, and wrap the "jacket" in an outer cover of sheet-iron.

When everything is ready, the boiler is connected to a stationary steam-plant and filled with steam at about 100 lbs. pressure. The engine is then given three running tests—two in forward, one in backward gear. This completes the shop tests.

It is not necessary to describe how the handrails, cab fittings, running-boards, and the many smaller details of the locomotive are assembled, or how the swivelling truck and wheels are placed in position forward of the cylinder. Not much time is wasted over painting, as in modern American locomotive construction *utility* always holds first place. The railway companies employ their engines just so long as they do their duties efficiently, and then send them to the scrap heap to make way for something better.

The process which has been here very rapidly sketched occupies, on the average, from two to three months. The shortest record at the Baldwin works stands at eight days for a narrow gauge locomotive —casting, boring, erecting, and testing all included. The erection occupies but a small fraction of the total time—five or six days after the boiler is set up till the engine is fit to go into active service.

In England some sensational performances have been witnessed in the erecting shops; and by the courtesy of the proprietors of *Engineering* these will be noticed at some length, as interesting examples of

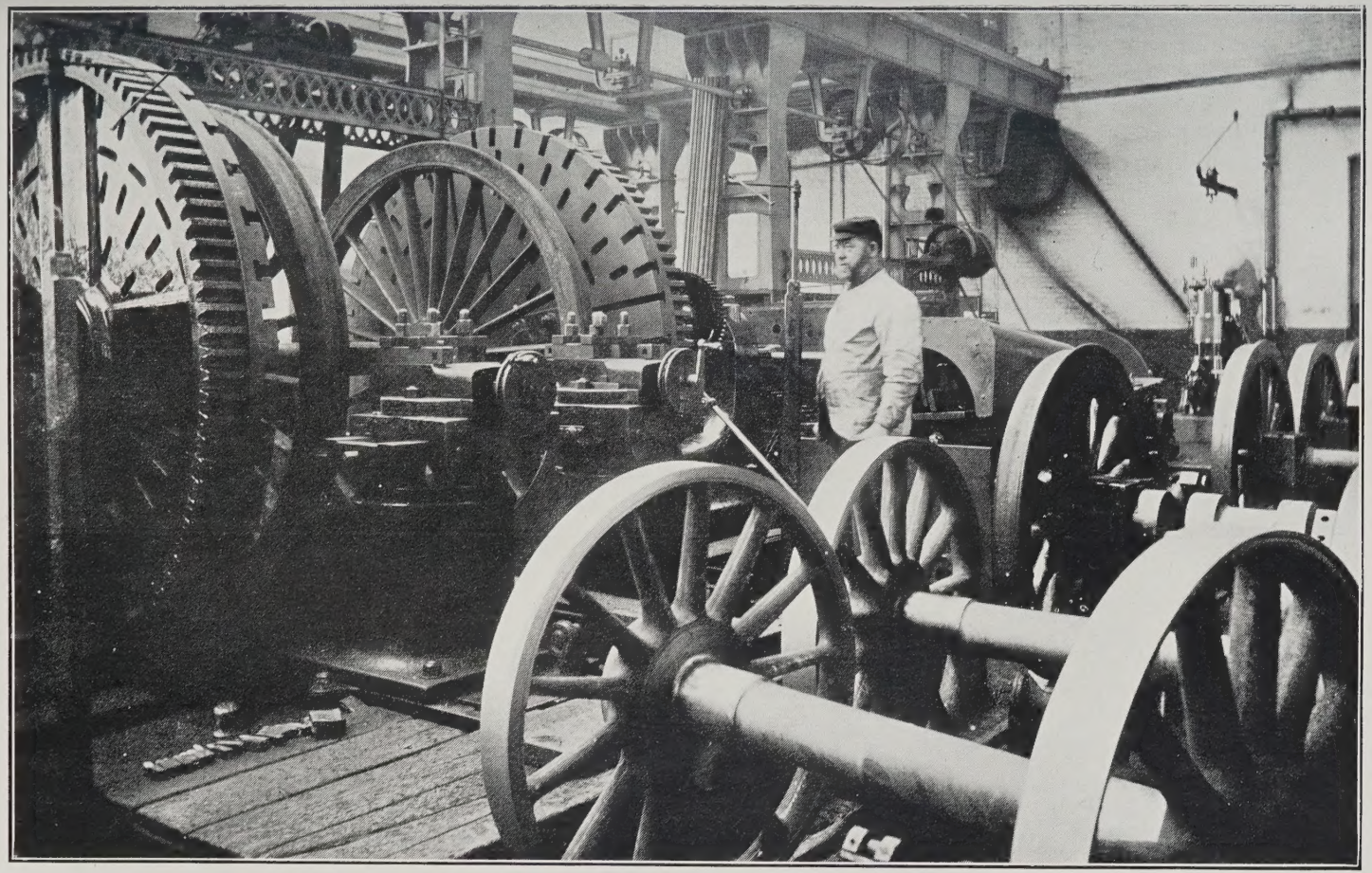

Photo by] [*F. Moore*

The Turning Shop, Horwich Locomotive Works.

On the left is seen a pair of driving wheels being trued in a giant lathe. On the right are wheels to which their steel tyres have not yet been attached.

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what a well-drilled body of mechanics can do at a pinch.

In February 1888 one of the London and North-Western standard six-coupled goods engines was erected at Crewe in 25½ working hours, the engine on its completion running a trial trip, and being then taken to the paint shop for final painting. Three years later this feat was completely eclipsed at the Great Eastern Works, Stratford, where a goods locomotive of the six-coupled type and its tender was put together *in less than ten hours!*

"A start was made at 9.8 A.M. on December 10th, the frame plates being laid flat on the ground with the horn-blocks and spring brackets fixed to them, but otherwise free of attachments, the work having been prepared in the same way as usual for the erectors. At 11 minutes from the start the first rivet was put into the frame, at 20 minutes the footplate casting was fixed, and at 26 minutes the motion-plate was in place. The setting and fixing of the cylinders occupied from 27 minutes to 1 hour 17 minutes from the start, while at 2 hours 37 minutes the setting of the motion was commenced and occupied until 3 hours 52 minutes, when the men left off for their dinner hour.

"Soon after recommencing work, namely, at 4 hours 7 minutes from the start, the boiler was put in place, it having had its mountings fixed and lagging put on prior to being brought to the erecting shop, but being without smoke-box or cab. At 5 hours

27 minutes from the start the engine was wheeled, the wheels having been supplied as they left the wheel shops, and the eccentric sheaves having to be fixed, and the axle-boxes and connecting-rods and coupling-rod brasses having to be fitted by the erectors. At 4.15 P.M., 6 hours 7 minutes from the start, the setting of the valves was commenced, this part of the work being still incomplete when work was stopped for the day at 5.30 P.M.

"On Friday work was recommenced at 6 A.M., and by 7 A.M.—8 hours 22 minutes from the start—the valve setting was completed and 40 minutes later the side rods were on. Prior to this—at 7.15 A.M.—painting had been commenced, and by 9.10 A.M., or 9 hours 47 minutes from the start (there having been an interval for breakfast from 8.15 to 9 A.M.), the engine was completed and was taken out of the shop to be photographed.

"During the erection of the engine the tender had also been in progress, it having been commenced at 9 A.M. on the 10th and finished at 7.40 A.M. on the 11th, the men working the ordinary hours. Later in the day the engine ran its trial trip, and was immediately put into regular work. It has since been continuously running with coal trains (weighing about 560 tons gross) between Peterborough and London.

"In erecting the engine the number of men employed was 85, made up as follows: Fitters (including three boys), 39; smiths, 2; boilermakers, rivet boys, &c., 44. On the tender the numbers were: Fitters, 16;

boilermakers, 16; labourers, 20; making a total of 52. . . . The *average* time for building an engine and tender is 8 days." It should be added that in this instance the usual number of men employed on an engine was trebled and those on the tender doubled.

As an instance of the durability of a well-built engine may be quoted the "Charles Dickens," which in the twenty years 1882–1902 made 5000 odd trips between Euston (London) and Manchester. During the *two million miles* traversed the engine did not break down once, and at the end of it all proved as fit for work as ever.

[The author has to thank Messrs. Burnham, Williams and Co., the present proprietors of the Baldwin Works, for the help they have given him in supplying information for this chapter.]

CHAPTER XVIII

WHAT THE EXPRESSES CAN DO

A BY no means uncommon type of mathematical problem found in school arithmetics is of the following nature: "A train moves at 60 miles an hour, propelled by a driving-wheel 7 feet in diameter. How many times per minute does the latter rotate?" Or the question may be inverted, and the speed in miles per hour resulting from a certain number of revolutions per second be required.

Well, 7 feet being about the standard diameter for English express "drivers," how many times a second would they have to turn to produce the mile-a-minute running? A mile a minute means 88 feet a second, and as the driving-wheel covers 22 feet every revolution, it must turn four times in that period. So that in the course of one minute the pistons, piston-rods, connecting-rods, and valves, have their direction of motion suddenly changed 480 times. This would speedily knock an engine to pieces were the moving parts not very nicely "balanced" by weights cast or attached between the rim and hub of the driving-wheels. As it is, the vibration on the footplate set up by the "reciprocation" of the machinery is very evident in the best built locomotive.

What the Expresses Can Do

When talking of express speeds we generally have two things in mind. First, the comparison of new with old records; secondly, the performances of the best "flyers" of various countries.

Under the first head it will at first sight appear that we have not made much advance. A reference to old statistics proves, for instance, that as long ago as 1848 a train covered 53¼ miles from London to Didcot in 47 minutes, or at 68 miles an hour, a speed that to-day is seldom beaten over such a distance. Also that the fast trains of forty years ago often reeled off their 50–55 miles an hour as a regular practice. Then turn to the modern time-table, and we find 60 miles an hour heading the list of daily train speeds.

Again, comparing the national expresses, and noting only the best performances, the reader might easily be led to suppose that the United States stand first for speed, France second, and Great Britain only third.

But on a closer examination of details we soon modify our opinions. There comes in the element of *averages*. Thus we find that the average speed of *all* modern English expresses is much higher than it was; that the average weight of the trains hauled is much greater; that the average journey is much longer. And under the second heading we discover that England's average express speed is much higher than those of America or France. After all, it is not the abnormal that determines the standard. To get down to figures: In 1888 it was found that in the

United Kingdom trains ran 62,900 miles per day at 40 or more miles per hour, while only 13,956 miles were covered at such speeds in the United States, and but 9000 in the whole of Europe. So that, if 40 miles per hour be made the qualifying standard for an express, the British Isles were at that date far ahead of all other countries. Since then the standard has been considerably raised all round, though Britain is left with a big lead.

Individual comparisons are proverbially odious, but often interesting. The fastest regular run in the world is done on the Philadelphia and Reading Railway by the "Atlantic Flyers," which cover the 55½ miles between Camden and Atlantic City in fifty minutes, a speed of 66.6 miles an hour. The Pennsylvania Company also runs an express over a different track between the same places at an average of 64.3 miles. For the next best performances we must go to France, where the 31 miles between Dax and Bayone are turned off in half-an-hour "dead," and after that we fall back to the 61.7 m.p.h. pace attained between Darlington and York on the North-Eastern. All three countries can boast several regular services in the immediate neighbourhood of "even time," *i.e.* a mile a minute.

So much for mere speed. Now we will consider the fastest long-distance trains of the world. Here France takes the first place with the Paris-Bayonne express, which covers the 486¼ miles in 8 hours 59 minutes, or 54.13 m.p.h. Second stands the New

York-Buffalo (440 miles) trip, performed in 8 hours 15 minutes = 53¼ m.p.h. And third comes the 50.77 m.p.h. of the Great Northern and the North-Eastern East Coast mail from London to Edinburgh (393⅓ miles).

On the count of non-stop runs England, as is only fair, comes out top. The Great Western now schedules expresses to cover the 246 miles separating London and Plymouth without a single pause. This, like the other journeys mentioned above, is a regular daily performance. On April 30, 1904, a train with the mails from the *Philadelphia* left Plymouth at 6.1 and reached Paddington at 9.55. Including slowing down at Exeter and Bristol the average rate was just over a mile per minute, and the whole run took a minute less than the previous record when the same company carried the Prince and Princess of Wales in the opposite direction.

In America the best schedule "break" is from New York to Troy, 148 miles, done in three hours dead; and in France the Nord's 185½-mile run from Paris to Calais Pier (3 hours 30 minutes) is the longest. On the whole, Britain stands easily first as a long-distance runner. The time-tables of 1903 show no less than 133 of her regular expresses exceeding a hundred miles between stops; the London and North-Western (33), the Great Northern (22), Great Western (23), and the Midland (16), taking the lion's share. America can claim about 50 journeys of 100 miles and over performed in daily service; and France some 25.

The "pick-up" water trough is used on these long breaks. Anybody who, after upsetting a glass of water on the tablecloth, tries to regain as much as possible of it with a spoon, employs the *principle* of the water-scoop which fills the tanks of a locomotive in motion.

A perfectly level stretch of line having been selected, a steel trough is laid centrally between each pair of rails. The trough, 6 inches deep, has a width of about 18 inches, and is made up of a number of sections riveted together, to give a total length of about 500 yards. Water is admitted to the trough automatically, so as to keep it at a depth of 5 inches, the surface being then about 2 inches above the rail. At the end from which a train approaches, an inclined plane leads to the trough, and there is a corresponding plane at the other extremity to lift the scoop out.

On approaching a trough the driver lets down his scoop, the lower or movable part of which contains a water-tight hinge. The impact drives the water through this and its connecting pipe into the tender. As soon as the latter is full, the water overflows on to the bank, or is returned by a pipe to the trough. Since the raising of the scoop requires a very powerful pull, this operation is often performed by the aid of steam or air pressure on a piston connected by a rod to the scoop itself.

For extraordinary speeds we must turn to the United States, where long, level, and straight stretches

enable the driver to "shake his engine up," as a coachman would say of his horses. Since 1890 the 100 miles-per-hour figure has been approached and passed on several occasions. Over 4.1 miles a Philadelphia and Reading express travelled at 98.4 miles per hour in 1890. Two years later a mile was covered in 37 seconds by a New Jersey Central train. But the most sensational performances are credited to the New York Central and Hudson River Railway, which can boast speeds of 102.8, 112.5, and 109.35 miles per hour. The last velocity was maintained in January 1903 for a distance of 7.29 miles. The record for steam locomotion is, however, at present held by a five-mile run over the Plant System's track from Fleming to Jacksonville, which occupied but $2\frac{1}{2}$ minutes, equal to 120 miles an hour! Some of these phenomenal bursts were the result of competition for the carriage of the mails, and at the time attracted as much interest as the racing of ocean greyhounds.

The fastest time on record for a run of over 440 miles falls to the Lake Shore and Michigan Southern Railways, which sent an express from Chicago to Buffalo (510 miles) in 8 hours 1 minute, equal to 65.7 m.p.h. exclusive of, and 63.61 m.p.h. inclusive of, stops! This was really a most extraordinary performance.

The United States are also *facile princeps* for transcontinental journeys. A mail and newspaper train on the Pennsylvania covers the 1058 miles between

New York and St. Louis in 20 hours, averaging 52.9 m.p.h. On August 4, 1903, the "Lowe Special" travelled from New York to Los Angeles (S. California), 3246 miles, in 73 hours 21 minutes (equal to 44.1 miles per hour). The run from Chicago to Los Angeles (2256 miles) was over the Atchison, Topeka, and Santa Fé track. When one considers the rugged nature of the country traversed for hundreds of miles in the neighbourhood of the Rocky Mountains, the speed appears nothing short of marvellous.

Canada's best is the exploit of the Japanese mail, when it ran from Vancouver to Brockville (2802 miles) in 77 hours 9 minutes, an average of about 36 m.p.h. India is far behind with a 25 m.p.h. average from Bombay to Calcutta. Australia boasts 37 m.p.h. for the 576½-mile trip between Melbourne and Sydney, exclusive of stops.

The finest running in Britain has been produced by the rivalry between the West-Coast and East-Coast routes to Scotland. The "Race for the North," fought out in two campaigns (in 1888 and 1895), was confessedly a trial of speed. The two competitors were the Great Northern and the London and North-Western, working in combination with the North-Eastern and Caledonian Railways respectively; and the prime cause of the struggle was the anxiety to secure the August holiday traffic. The Great Northern had in May 1888 announced that it meant to run *third*-class passengers to Edinburgh in 9 hours. The North-Western, in the following month, reduced its time to

8½ hours. The other competitor therefore decided to inaugurate in August an *eight-hour* service; a challenge which the Euston authorities were quick to take up, fixing 7¾ hours as the time to be occupied over the journey. The Great Northern, however, did not mean to be beaten, and scored a record of 7 hours 32 minutes. Then a truce was made, and the two rivals, after piling up a few more records, settled down to 7¾ hours for the East and 8 hours for the West-Coast journey.

In 1895 they were at it again; but now Aberdeen formed the objective. In June the best times were—11 hours 35 minutes for the East Coast (523 miles), and 11 hours 50 minutes for the West Coast (540 miles). By August 22 these had been improved upon by 2 hours 57 minutes and 3 hours 10 minutes respectively; the West Coast performing the whole distance at an average of 63.3 m.p.h., stoppages included.

"Does high speed pay?" is a question often asked by the practical man, who is apt to regard these *tours de force* much in the light of a mere exhibition of the record-making spirit that pervades humanity.

This is the answer of Mr. Charles Rous Martin, an expert on all matters connected with railway performance and practice, as given in the *Engineering Magazine:* "Since the accelerations of 1895—usually called 'the Race to Aberdeen'—there has been an enormous expansion of the Anglo-Scottish traffic. For many weeks during July, August, and September the principal expresses, which have been more than doubled in number, have to be sent off day after day

in duplicate and even triplicate; and I have known fourteen heavy expresses despatched on a single evening from one London station to Scotland, instead of the four shown on the time-table. But I may be asked how I know that the acceleration have done this. My answer is that the people who now go and formerly did not, have said to me that they had imagined the journey to be far longer and more tiresome than they found it actually to be, and that the truth was brought under their notice by the 'racing' of 1895, and the subsequent acceleration of the regular trains. When they read that trains had reached Aberdeen—*ultima Thule* in their previous ideas—from London in 8 hours 30 minutes by the West Coast, and 8 hours 40 minutes by the East Coast; Perth in $7\frac{1}{4}$ hours, and Edinburgh 6 hours 19 minutes; and all this without the slightest hitch or mishap, they realised that neither the distance nor the journey was so very formidable after all. So they tried it; and having once tried it, they now go to Scotland year by year, and will continue to go. Is there any reason to doubt that the experience of these particular persons who communicated it to me is also that of many others, and that here we have the true explanation of the last quinquennium's traffic development? I think not. High speed is an excellent advertisement."

The risks supposed to attend fast travelling are, so far as concerns speed itself, non-existent. On a properly laid track a train is no more likely to leave

the metals when travelling a mile a minute than when doing but 30 miles an hour. And as for collisions, the express is watched over with special care, and, if it accidentally charges into a stray truck or fallen tree, that disaster cannot be attributed to its velocity. It may with justice be argued that we have to thank our expresses for the great security which characterises railway travel; since necessity has been the mother of the many wonderful inventions incorporated into signalling and braking apparatus.

The value of quick transit is by no means confined to passenger trains. We hear a good deal now of "express goods," often worked by passenger locomotives. By getting goods quickly along the line and off it again a much greater bulk can be handled than with a lower standard of travelling speed. To shift long strings of waggons more powerful engines are being built from year to year, notably in America and France, where enormous goods trains are hauled at comparatively fast speeds to clear the line for the passenger expresses.

So strong is the craving for rapid movement in this bustling age, that a good many people prefer waiting for a fast train to taking a "local" at once which may get them to their destination at an earlier hour. There is, no doubt, something in the mere fact of swift motion which goes a long way to remove the tedium of a journey, whether of 30 or 300 miles.

CHAPTER XIX

THE RAILWAY IN WAR

WHEN our thoughts turn back to the many stirring events of the Boer War how often the railway obtrudes itself into them ! First, there is the scene at the English station, where the Regular, Yeoman, or Volunteer is bidding farewell to those he loves ; a scene of deep sorrow underlying all the cheers and handkerchief-waving that accompany the train as it slowly draws out of the platform with its load of "troops for the front." At the Cape the same men are entrained a second time, in trucks maybe, and borne for hundreds of miles across the rolling sandy veldt to where they will have a chance of at last coming to handgrips with the enemy. Behind the troops roll up long trains of provisions for man and beast ; trains bearing the deadly artillery ; trains fitted up with all the appliances of a hospital ; trains of horses that will, ere many weeks are out, leave their bones to whiten under the stars.

Earlier in the war we read of trains packed with English fugitives from Pretoria and Johannesburg—strong men and delicate women, all sorely tried by fatigue and heat, hunger and thirst, the taunts of their enemies and the knowledge that they have left all

their worldly possessions behind them to take the chances of war. Then there come down the same line supplies for the Boer army now advancing on their hardy ponies to meet the English army of Natal. Soon follow in quick succession the battles of Dundee and Elandslaagte, the hurried retreat, the disaster at Nicholson's Nek, and the investment of Ladysmith ; from which General French escapes in the last train that left the town.

Whichever way we look, or to whatever period of the war, the railway looms large, for it was in many districts the sole means of transporting troops and supplies. The very first act of hostility was the derailment by the Boers of a train at Kraaipan. For months the sound of dynamite, doing its fell work on culverts and railway bridges, was heard. Every other day we read of a train being derailed and burnt, after the mails had been scattered to the winds, and of the exploits of armoured trains. At Mafeking an engine laden with explosives is sent flying along the track towards the besiegers. From Pretoria the President escapes over the railway to the ship awaiting him at Delagoa Bay. Far up in Rhodesia men are being painfully transported from Beira to Salisbury along the ricketty narrow gauge, and southward to the relief of Mafeking. When the tide turns in favour of England the engineer gets to work, mending the ruined culverts, replacing the shattered bridges, clearing the ruined tunnels. Engines and rolling-stock are captured and accom-

pany the advancing army to Bloemfontein and Pretoria, whence they presently return crammed with captured Boers. The British soldier, a thousand miles from the Cape, was utterly dependent on the steel bars that ran through country inhabited by people who, if they were not openly against us, were certainly not on our side. Again and again communications were cut by a few pounds of explosive laid cunningly on the track.

A hard task indeed fell to the lot of the men who had to watch, organise, and control the railway traffic. There was no class more worried and worked than the railway staff-officer. He rose in the small hours of the morning, and till late at night was engaged in a constant struggle with a host of perplexing problems—the provision of vehicles to transport large bodies of troops, stacks of stores and military equipment; the endeavour to do his duty by a host of superiors all requiring their own particular needs to be attended to first; the reading and despatching of cypher telegrams when his head was already dizzy with two good days' work crowded into one. Yes! the traffic manager of an important English railway had an easy time as compared with the gentleman who at some wayside railway station in the Colony tried to hold the balance between the military and railway authorities.

Thirty years before the Boer War a very similar state of things was existent in France, when the Germans and French were locked in the most

terrible conflict of modern times. The Germans have pushed their armies across to Paris and are feeding them, reinforcing them and supplying all the munitions of war over the railway. Bridges and tunnels have been blown up; desperate men have struck desperate blows for their country by wrecking trains; but the conquering flood still rolls on. There is the same tremendous activity at the railway depôts.

"Apart from its importance, there was not a more interesting place in the whole of the occupied country than the Nancy railway station. At that great cross-road on the highroad of the invasion, where the Saarbrück-Paris line and the Strasburg-Paris line converge and unite, every minute some picture belonging to and formed out of the war, presented itself. The beautiful city of Nancy, which, as a whole, is not less beautiful than Paris, and which in proportion to its size possesses more fine streets, spacious squares, and picturesque gardens than any city in France, had returned in a great measure to its normal condition. . . . But the sight of French prisoners always affected the kind-hearted Nançois, and painful scenes used often to occur when prisoners were marched in large bodies through the town. After the surrender of Toul the prisoners were all sent to Strasburg or to Saarbrück by rail; and the railway bridge at Nancy was crowded with sympathising spectators whenever a convoy of prisoners reached the station. . . . The German

Governmental authorities therefore erected a hoarding on each side of the railway bridge at Nancy, so that no one might see the trains of prisoners arrive. In view of these unexpected barricades the townspeople armed themselves with gimlets, and the boards were soon perforated in all directions, and the bridge was crowded whenever it was known that a fresh convoy of captive Frenchmen had come in."[1]

The importance of keeping open their railway communications was such that the Germans took a very strong line with would-be train-wreckers. To remove rails or place obstacles on the line was a capital offence, when the culprit could be found. If he could not, a fine of 1000 thalers was imposed on the nearest commune, or, if it could not pay, on the members of the municipal council of the nearest town.

The invaders brought with them five railway detachments, whose business it was to repair any damage done to the line by the invaded. These detachments consisted of navvies and engineer troops. When the army advanced they reconnoitred the lines, removed obstructions, restored broken bridges, adapted the existing stations to military purposes, built new stations where required, and directed the traffic. In case of a retreat, on them devolved the rôle of destroying the track sufficiently to impede the enemy.

At Nancy engines of all kinds had been collected in large numbers. French and German locomotives

[1] "The Germans in France." H. Sutherland Edwards.

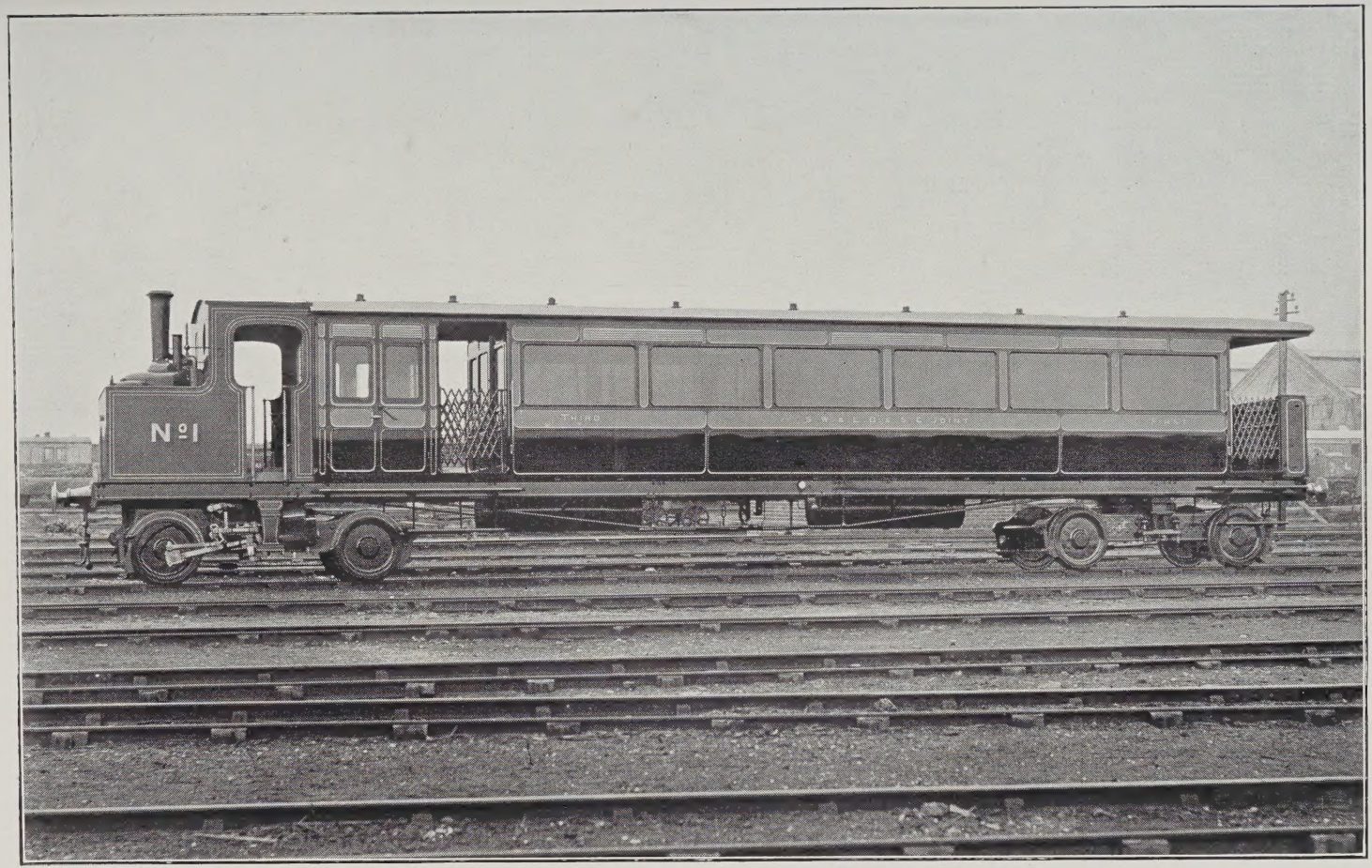
jostled one another on the four main lines and in the innumerable sidings. "At times every inch of line," says Mr. Sutherland Edwards, "was covered, and the trains extended half a quarter of a mile beyond the station each way. To look for any particular train was like looking for a carriage on Epsom Downs; but you could make your search if you liked; . . . you might walk between the trains, cross between the carriages, jump into a carriage while the train was in motion, jump similarly out of it, keep the carriage doors open or shut as you felt inclined, do anything in short except drive the engine."

French engine-drivers and signalmen were impressed to work the sections of the line that they knew. In order to prevent train-wrecking, prominent French citizens were often carried on the engine, where, in case of an explosion or accident, their safety would be imperilled even more than that of the troops in the carriages behind. Armed guards also kept watch over the drivers to see that they did what was required of them. On one occasion a driver and his stoker overpowered the soldiers and threw them off the engine. They uncoupled the latter in the middle of a tunnel and made off with it until they had covered a mile or more. Then they reversed the gear, turned on steam, and sprang off, leaving the locomotive to dash back into the train and work havoc among their enemies. Such actions, however, rarely occurred, fortunately for the French,

since they only served to make the lot of the vanquished harder than it had been before.

As soon as the Germans had a firm grip on a length of railway they proceeded to send artillery over it for the siege of Paris. Hundreds of guns of all weights and ages were loaded into trucks, along with suitable ammunition, of which huge quantities were expended before the capitulation of the metropolis. Here and there, in the neighbourhood of a town, and therefore within reach of its guns, the railway had to be deflected on to a temporary track which "turned" the obstacle, since the guns must be brought up at all costs. In October 1870, 230 pieces of artillery from Germany were delivered at Nanteuil, whence they were distributed by road to the various positions surrounding Paris.

The Germans had one great advantage over the English as regards the use of a railway as a means of support, in that, supposing the track had been destroyed, they would still have the excellent roads for which France is famous to fall back upon. As we know so well from printed accounts and photographs, South African roads are alternately dust trails and quagmires, punctuated by terribly difficult "drifts," through which long teams of oxen painfully hauled waggons and artillery. Furthermore, our troops were not able to "live on the country" as did the Germans. They could not requisition food when there was no food. For sustenance, they depended entirely on the railway.



A Railway Motor Car used on the London and South-Western Railway for Local Passenger Traffic.

Similar vehicles are also employed on the Great Western and North-Eastern systems.

[*To face p.* 304.

In turn, Russia's present position is infinitely more precarious than that of Britain at any period of the Boer War. For five-sixths of the total distance to the front our troops were transported in commodious vessels, maintaining an uninterrupted speed of 18–20 miles an hour for weeks on end. And when they reached dry land below the Equator, they might be carried to the front on any one of four tracks—from Cape Town, Port Elizabeth, Durban, Beira—as occasion demanded; and three of these lines were well laid.

Contrast with these facts the case of Russia in her struggle with Japan. She possesses one possible means of communication between Europe and the easternmost parts of Asia, a line nearly 6000 miles long, which has recently cost her £100,000,000, is for the most part badly built, and strategically weakened by the break at Lake Baikal. The difficulties arising from imperfect construction are aggravated by natural obstacles, chief among which is the intense cold that for many months in the year aids the winds to smother the track under deep drifts of snow. Have we not read of congestion of traffic, the sufferings of the soldiers, the utter disorganisation resulting from the sudden tremendous calls made on this immense railway by the outbreak of war at its eastern extremity? There have been plenty of rumours of bridges wrecked by secret agents, an apparently inevitable feature of a contest in which railways play a part. We read, too, of attempts made to destroy

trains, after quite the approved methods of the Franco-German war. A favourite device, and one that has often been resorted to, is for some person, evidently familiar with locomotives, to creep into the engine sheds by night, get up steam on an engine, switch it on to the main line, and then let it run wild, after jumping to the ground. Such attempts have ended in failure, thanks to the telegraph, which has enabled the signalmen to turn the runaway into a siding before it encountered a train.

On account of the secrecy observed by the Russian authorities with regard to the management and fortunes of the line, little reliable news has filtered through to us. We are fully aware of the strenuous efforts needed to hurry large numbers of fresh troops into Manchuria, and to feed them, if the Russians are to have any chance of ultimate success. The situation centres on the railway; if it proves utterly unequal to the strain cast upon it, Russia's hold of Manchuria is gone. As a correspondent of the *Daily Express* puts it: "It (the railway) is the artery of the war. If the accident of nature or the schemes of the Japanese should fasten a ligature upon it, the Russian cause in the Far East must decay and perish."

Apart from its importance, then, there is nothing much to be said of the Trans-Siberian Railway as a war machine. But in America, when the States were convulsed by their terrible Civil War, many a romantic incident was connected with the iron road. Some of

the boldest raids of the cavalry leaders on both sides had as their object the destruction of railways. Bridges were smeared with tar and fired; rails were torn from their ties, heated in bonfires, and twisted so that they could not possibly be replaced. Then up came a body of troops representing the other side, and workmen organised for this especial service would quickly repair the injured track, and trains would shortly be running as before.

It soon became evident that for a really serious destruction of railway property the destroying force must occupy the line for a considerable period; and some desperate fighting was witnessed before the stronger party finally managed to tighten its grip on a railway. Then the destroyers set to work in earnest, showing, as has been said, almost as much ingenuity in preparing means for its ruin as had previously been evinced in its erection. Military writers of the United States ordered that not only should the piles and woodwork of the bridges be smeared with tar, but shells and grenades with fusees of various lengths should be arranged to keep up recurrent explosions, in order to prevent any attempt of the enemy to extinguish the fire. In case of a bridge being inaccessible, heavy timber rafts were to be sent down the current to smite them like battering rams; and if these failed, fire vessels should be tried, or floating torpedoes exploded by electricity.

The siege of Atlanta, where the Confederate army had taken up its position against General Sherman,

was brought to a successful issue for the Federals only after Sherman had effectually severed the railways connecting Atlanta with the Southern States. The general in person superintended the work of demolishing the track. "For twelve and a half miles," writes one of his staff officers, "the ties were burned, and the iron rails heated and twisted with the ingenuity of hands old to the work. Several cuts were filled up with the trunks of trees, logs, rocks, and earth, intermingled with loaded shells, prepared as torpedoes, to explode in case of an attempt to clear them out."

In the neighbourhood of Atlanta one of the most stirring events of the early part of the war was enacted; and as its scene was the railway, it may suitably be described in some detail.

In March 1862 the Federal and Confederate armies were approaching each other in Tennessee, Georgia, and Alabama. The former, under General O. M. Mitchell, occupied Nashville and Shelbyville on the line running south from Louisville and Cincinnati. The Confederates, who were pushing up northwards, had their base at Atlanta, and held the railway which put that town, *viâ* Chattanooga, in communication with Corinth in the west and Richmond in the east. It was along this line—connected, by-the-bye, with the Nashville branch—that their advance lay; and as long as they occupied it there was a serious danger of a wedge being driven in between the two Federal divisions.

Some men therefore volunteered to enter the Confederate lines in disguise and work their way down the railway to Atlanta, where they hoped to be able to capture a locomotive and return north, burning and blowing up bridges as they went, and otherwise rendering the track useless. They reached Atlanta safely, but owing to the absence of the engine-driver who was to have joined them there, they had to abandon the project and return to their own party as best they might.

The leader, Mr. J. J. Andrews, a Kentuckian, did not give up hope. He asked for a larger number of men to help him in a second attempt, and in response so many volunteers came forward that he was able to select twenty-three persons best suited for the work in hand. These included five engineers, so that in case of a mishap there might still be left one or two capable of running a train. The brave little band were drawn from the Twenty-first, Thirty-third, and Second Ohio Regiments.

On his first expedition Mr. Andrews, a man of fine presence and one who, by his manners and bearing, could easily pass himself off as a cultivated southern landowner, had possessed himself of a time-table showing the hours at which trains would leave the various stations between Atlanta and Chattanooga. The party assembled by night at an appointed rendezvous in a wood, and there received their final instructions. They were to separate into several groups and travel on foot or in hired convey-

ances to some station on the Memphis and Charlestown Railroad near Chattanooga, and thence travel by rail to Marietta, a station a little north of Atlanta. In order to avoid suspicion they must represent themselves to be Kentuckians going south to escape the Federals and join the Confederate army. If suspected, they should at once enlist in the enemy's ranks.

After many adventures the gallant twenty-four found themselves in the small hotel outside the Marietta depôt. Their position was indeed perilous. As one of them said, "Our doom might be fixed before the setting of another sun. We might be hanging to the limbs of some of the trees along the railroad, with an enraged populace jeering and shouting vengeance because we had no more lives to give up; or we might leave a trail of fire and destruction behind us, and come triumphantly rolling into Chattanooga and Huntsville, to receive the welcome plaudits of comrades left behind, and the thanks of our general, and the praises of a grateful people."

The men were to embark on an early morning train and travel in it as far as Big Shanty, where it halted to allow the passengers to get some breakfast. Then would come the chance of uncoupling the engine and a few cars from the rest of the train, and making off with them.

This programme was carried out to a nicety. When the conductor, engineer, fireman, and passengers had adjourned to the refreshment room,

the conspirators quickly distributed themselves into their allotted places, and before a cry could be raised the locomotive and three cars were speeding northwards on a journey such as has never been paralleled in railway annals.

The steam soon gave out, and it became necessary to halt and replenish the furnace with wood. The fugitives built their chief hopes upon the difficulty that the Southerners would experience in getting hold of an engine to send in pursuit. At Kingston, thirty miles north of Big Shanty, they would meet an irregular train, and, that once passed, they expected to run at top speed for the nearest bridge, burn it, and hurry on, serving every other bridge they crossed in a like manner. As they went they would destroy the telegraph, so that no messages could be flashed back to Atlanta.

Keeping on regular time, they reached Kingston, two hours after the capture of the train, without having in any way damaged the line. As their own train had been scheduled as irregular, Andrews claimed to be a Confederate officer of high rank, who was running a special powder-train through to the army of General Beauregard at Corinth.

Unfortunately, the local southward-bound freight was late at Kingston, and the conspirators were obliged to lose valuable time in a siding. At last it arrived, and passed. But it carried a red flag, signifying that *another* train was just behind it, and must also be awaited. On this Andrews had not

calculated; and the fact was soon explained by the conductor of the first train, who said that the Confederate rolling-stock was being hurried south before the advance of General Mitchell.

To wait would have been fatal. Andrews decided to risk a collision, and ran his train on to the main line. A minute later it was flying north at forty miles an hour for Adairsville, in the hope of reaching that station before the expected freight. A short distance south of this station the train stopped, and the men dismounted to cut the wires and remove a few rails, which were loaded on the cars along with some sleepers that happened to be stacked there. At Adairsville they met and passed the expected freight, and a passenger train at Calhoun. The road then lay clear to Chattanooga. Their hopes rose.

A little north of Calhoun was a bridge spanning the Oostenavla River which they had determined to burn. As a precautionary measure, Andrews decided to remove a rail to obstruct pursuit by any of the trains which had been passed. They had just wrenched this free when, to their dismay, they saw an engine bearing down upon them! The pursuit had indeed been pressed hard!

We must now return to Big Shanty, and briefly follow the doings of Fuller, the conductor of the captured train.

As the locomotive left the platform, Fuller and two companions pursued it on foot amid the jeers of their companions. He expected that the fugitives would

abandon their prize as soon as they had cleared the Confederate outposts, and he therefore hoped to be able to retake the engine and bring it back to his train. But some severed telegraph wires soon undeceived him.

The three fell in with a party of workmen and a hand car. These were at once pressed into the service, and the pursuit now continued at seven or eight miles an hour. Their one hope of success rested on finding at Etowah, 13 miles from Kingston, an engine which worked a branch line to some ironworks. Great was their delight when they saw the old "Yonah" standing in the station, its head turned towards Kingston. On to it they sprang, and their former crawl quickened into nearly a mile a minute. But when Kingston was reached the birds had already flown. Here they changed engines, and with a force of a hundred armed men continued the pursuit until, beyond Calhoun, they sighted their quarry.

Transferring our attention once more, we will join Andrews and his party.

As they had a rail removed between them and their pursuers, they hoped to be able to burn the bridge before the damage could be put right. But Fuller's train managed, in an almost miraculous manner, to clear the gap and continue merrily on its way. The driver attributes this extraordinary feat to the fact that the blank occurred in the *inside* rail and on a curve. As the train was travelling at a very high speed its weight was thrown mostly on the *outside*

rail, and kept up against it by centrifugal force. With quick decision he increased the speed, and after a sharp jolt the engine and its cars were on the farther side of the gap. Had Andrews removed an outer rail, the whole history of subsequent events would have been altered.

Seeing that it was now impossible to fire the bridge, the brave Northerner cast loose a car in the hope that it might wreck the pursuing engine. But Fuller pulled up in time, and, picking up the car, proceeded, pushing it before the engine. A second car was then dropped, with as little effect.

The fugitives next proceeded to throw the sleepers they carried on to the track, and so managed to impede the "Shorter," as the other engine was named. Short halts were made to cut the wires and take in water and fuel. As long as the pursued had anything on board which could be used as an obstruction, the pursuers were obliged to keep at a respectful distance—just far enough behind to see what was being done by those in front.

Thus the chase continued mile after mile at express speed. Idlers in the stations were amazed by the sight of a train dashing past closely followed by another. To the travellers the country appeared to spin past giddily; then the leading engine would be suddenly reversed, and the brakes applied with such suddenness as to cause the occupants of the one remaining car to cling tightly to its sides. Scarcely had the wheels ceased to revolve when the Northerners

were on the track, desperately loading ties or cutting the telegraph wires. At the signal all sprang aboard again, and the engine bounded forward once more at such a pace that it was a wonder how it kept on the rails at all.

Mere speed could not, however, save Andrews' party from an even swifter engine. Not far ahead of them now lay Dalton, a junction for the lines running east and west. It was the southern apex of a triangle of lines, the other two corners being at Cleveland and Chattanooga. If they managed to clear Dalton it would be of no avail, since news of the flight would reach Chattanooga *viâ* Cleveland before the locomotive. However, they passed Dalton unmolested, and soon entered a tunnel where they determined to play their last card. With great difficulty they set the car ablaze, and cast it adrift on a long covered bridge. The other party simply pushed it ahead to the next siding and left it there to burn.

Little now remained but to abandon the railway, and make for the Northern Army across country, through the woods and mountains. Some of the bolder spirits did, indeed, suggest that it would be worth while to form an ambuscade near an obstruction, and, while the pursuers were hard at work, to fire upon them, board their train, and send it flying back to collide with the one following behind. But Andrews overruled the suggestion, and the flight continued at a slower speed, as the supply of fuel now began to fail. Twelve miles from Chattanooga the

fugitives reversed their engine, jumped off, and left it to do any evil that the exhausted furnace could urge it to. Fortunately for those behind, the "General's" force was expended, and it came to a standstill before reaching them. With the subsequent adventures of the brave twenty-four—their capture, imprisonment, the execution of eight (including Andrews), the escape of eight more, and the final exchange of the remainder—we will not here deal, as they are in no way connected with the railroad. It will be interesting, however, to notice the opinions held by both sides as regards the importance of the enterprise which so nearly succeeded. "The expedition failed," says Judge Advocate-General Holt, in a report to the Secretary of War, "from causes which reflected neither upon the genius by which it was planned, nor upon the intrepidity and discretion of those engaged in executing it. But for the accident of meeting these trains, which could not have been anticipated, the movement would have been a complete success, and the whole aspect of the war in the South and South-West would have been at once changed. The expedition itself, in the daring of its conception, has the wildness of a romance; while in the gigantic and overwhelming results which it sought, and was likely to accomplish, it was absolutely sublime."

A Southern journal says: "We doubt if the victory of Manassas or Corinth were worth as much to us as the frustration of this grand *coup d'état.* It is not by

any means certain that the annihilation of Beauregard's whole army at Corinth would be so fatal a blow to us as would have been the burning of the bridges at that time and by these men."

The pluck shown by Andrews and his comrades was equalled by the determination of Fuller and his party. The people who at Big Shanty mocked the conductor as he pursued the train on foot little knew that that pedestrian feat was to avert a great disaster from the Southern arms. Fuller thoroughly deserved all the credit he got.

Note.—For a more detailed description of this incident, the reader is referred to "Capturing a Locomotive," by the Rev. W. Pittenger, who was himself one of Andrews' associates.

CHAPTER XX

THE ELECTRIC RAILWAY

IT may be asked, "What has electricity got to do with the romance of steam locomotion?" Just what the Romans had to do with the Carthaginians, or the English of Elizabeth's day to do with the Spaniards. You cannot discuss the fortunes of an individual, a nation, or an invention without some reference to the rivalry to which each is subject.

Steam locomotion is, at the present time, being hard beset by two powerful rivals; the one, electricity, most evident in connection with vehicles that move on rails; the other, the energy of the petrol engine, which propels carriages over rails and roads. To appreciate how formidable a competitor the former is, we have only to look round the metropolis of any highly civilised country. The horse, as the patient mover of the tramcar, will soon be seen no more. In London, simply on account of the inconvenience of relaying the tracks, the surface electric car has not yet become general; but in the suburbs and large provincial towns the subtle current has driven our faithful four-legged servant out of the field. The fight is rapidly extending to urban and suburban railways, both on the surface and

below. The many "tubes" that burrow like huge mole-runs through London clay and gravel are all worked electrically. The Metropolitan Railway, which for forty years has filled our lungs with sulphurous fumes, will also soon find itself metamorphosed into the abode of clean, fresh air. Some of the suburban steam railways are also being weighed in the balances, and if they prove wanting, as compared with those already dominated by the electric current, they too will alter the fashion of their motive power. The same story can be told of Paris, Vienna, New York, Boston, and other large cities; and schemes are already mooted for converting stretches of track, hundred of miles long, notably in Italy, Switzerland, and the United States.

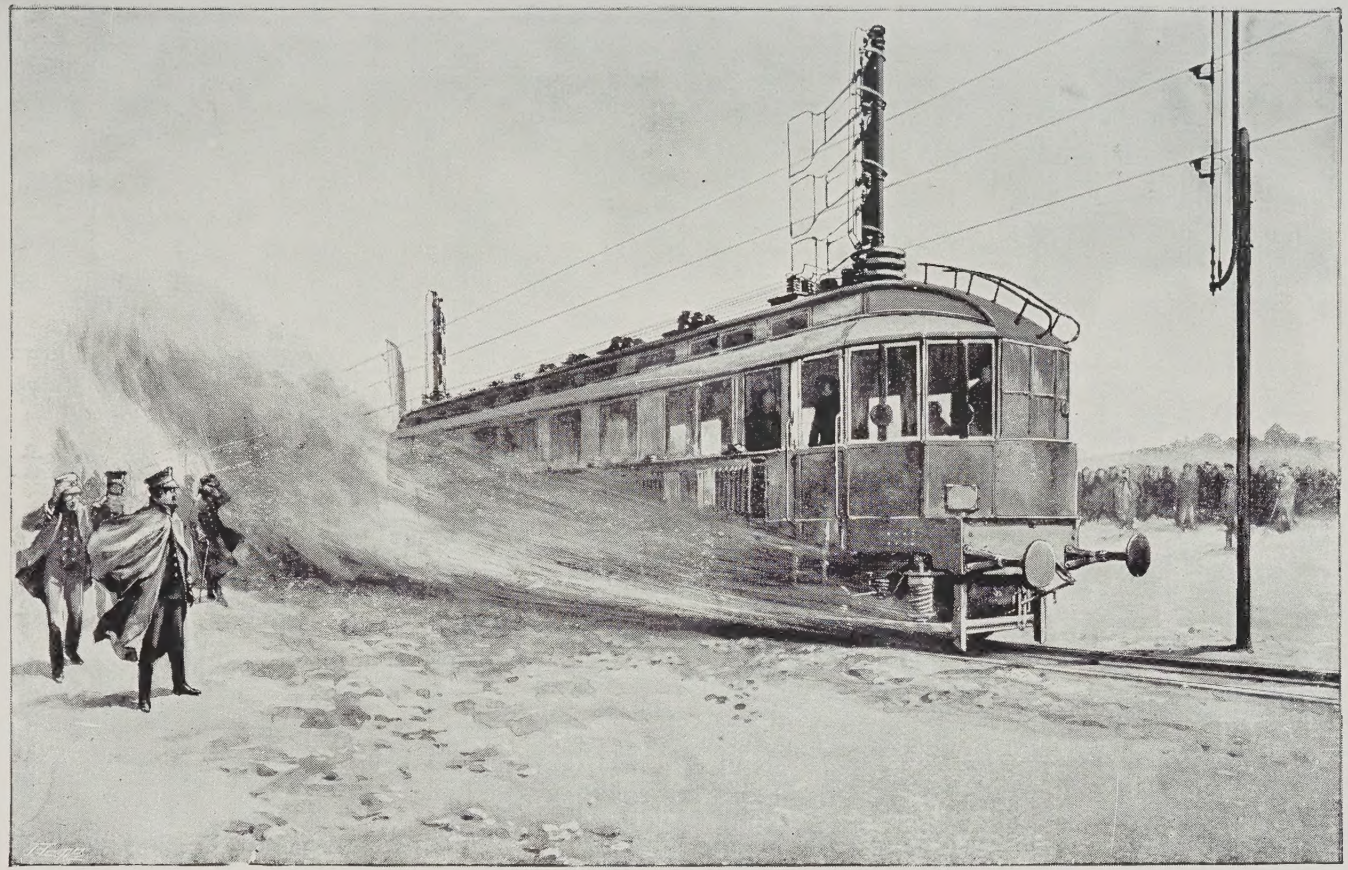
The last-named country may with justice be termed the cradle of the electric railway. It contains no less than 150 such tracks over 50 miles in length. New York has been joined to Boston by an electric line —185 miles in length. The Jersey City electric system now reaches to within a few miles of Philadelphia. The New York Elevated has shelved its steam-engines; so has the Manhattan Elevated. In short, the era of electric traction has already left its dawn some way behind, and is making its influence seriously felt in the dominions of King Steam.

The great advantages claimed for the electric motor are,—its cleanliness; its rapid acceleration of speed; the flexibility which it gives to all traffic that it works.

Every electrically-driven vehicle can be run independently, or as a unit of a series; so that the size of a train may very easily be accommodated to the number of the passengers that it will have to carry at different periods of the day.

A further point in favour of the employment of electricity arises from the ease and cheapness with which it can be generated in countries where large water power is available. By deflecting mountain streams and waterfalls into the maws of turbines, a huge quantity of hitherto wasted natural energy is brought into the service of man, and so transformed that it can be led hither and thither through a small wire.

Because the electric railways with which we are at present acquainted do not to any great extent surpass their steam rivals in speed, it must not be inferred that the electric locomotive is necessarily a "slow hoss." Several years ago an accumulator-driven motor was tried on one of the French railways in the place of the steam locomotive which usually drew the express, and it gave a very good account of itself, attaining in places, with a heavy load, a speed of 60 miles an hour. This machine was only of the nature of an experiment, as the expense of laying wires along the track to supply a motor with current would have been too considerable. The ordinary electric locomotive of to-day is not self-contained like the steamer. It is merely furnished with motors to transform current generated elsewhere into power,



Berlin-Zossen Railway. Travelling at top speed, 130½ *miles per hour.*

This immense velocity creates a perfect sandstorm along the track. The draught picks up stones and hurls them against the bottom of the car.

[*To face p.* 320.

contact being made with the source of supply either by means of a third and insulated rail laid between the two wheel rails, or through a trolley arm carrying a wheel which runs along an overhead wire.

The following quotation from the old "Thunderer" gives an insight into the electrification of American railways. "At Los Angeles, California, an important network of tramways has been started by the Pacific Electric Railway Company, the president of which is Mr. H. E. Huntingdon. From a conversation I had with him, I found he is strongly convinced that the tractive force of the future is electricity, notwithstanding the fact that it was from the steam railways that his famous relative made his fortune. The Company in question was only formed in February 1902, yet by the following July it had completed and begun to operate a new line of tramway between Los Angeles and Long Beach, a favourite seaside resort 21 miles distant. . . . The cars start from the streets of Los Angeles in the ordinary way; but as soon as possible on reaching the outskirts of the city they leave the highway, and enter on what seems to be, to all intents and purposes, an ordinary railway line, fenced in on each side and having a double set of rails, but provided with overhead wires for the electric current. There are very few curves in the track, and the grade is uniform throughout, while the road-bed of the line seemed to be as solid as that of any well-built railway. Our car being a 'special,' it ran express from Los Angeles to Long Beach, and

the journey of 21 miles was done in just over half-an-hour. But the company expect that when they get the full amount of the power for which they have arranged they will run their 'express' cars at the rate of 60 miles an hour, though the full equipment would then allow of a speed of 75 or even 90 miles an hour. Any such speed as this would, of course, be maintained only along those parts of the track which represent the private right of way, and would not be attempted either at Los Angeles or at Long Beach, where the ordinary streets are passed through. These developments at Los Angeles are significant of a great deal that is going on in the United States, though the Company in question may be in an especially favoured position, because it hopes eventually to get electricity equal to 25,000 horse-power at a cost of only about half a cent. per horse-power per hour, by generating it at the Kern River, and conveying it thence to Los Angeles, a distance of 200 miles." [1]

A good deal has been heard and written lately about the projected monorail line between Manchester and Liverpool. Mr. F. B. Behr is the chief exponent of this form of electrically-driven railway; the main feature of which is that the metals are mounted on the apices of a succession of trestles, so as to allow the carriage to hang saddle-fashion, a part on each side. He built an experimental track seven miles long to connect the Brussels Exhibition of 1897 with Tervueren. The rail ran 4 feet above the sleepers on steel

[1] The *Times*, June 5, 1903.

trestles bolted down to sleepers of the same material. To quote from another place[1] :—

"The carriage—Mr. Behr used but one on this line—weighed 68 tons, was 59 feet long and 11 feet wide, and could accommodate 100 persons. It was handsomely fitted up, and had specially-shaped seats, which neutralised the effect of rounding curves, and ended fore and aft in a point, to overcome the wind-resistance in front and the air-suction behind. Sixteen pairs of wheels on the under side of the carriage engaged with the two pairs of guide-rails flanking the trestles, and eight large double-flanged wheels, $4\frac{1}{2}$ feet in diameter, carried the weight of the vehicle. The inner four of these wheels were driven by as many powerful electric motors contained, along with the guiding mechanism, in the lower part of the car. The motors picked up current from the centre rail and from another steel rail laid along the sleepers on porcelain insulators."

This car attained a top speed of 90 miles an hour. Mr. Behr, encouraged by this performance, obtained Parliamentary powers to build a similar line over the $34\frac{1}{2}$ miles separating "Cottonopolis" and Liverpool. At present matters have not gone beyond the paper stage, and the citizens of these two great towns must still content themselves with the 45-minute express service available on these separate lines. Perhaps in a few years we may see the strange balanced cars flying along at the 100-mile-an-hour pace promised by Mr. Behr.

[1] "The Romance of Modern Invention," p. 264.

As we noticed in Chapter XVIII., 90 miles an hour has been soundly beaten by the express steam locomotive, which has a mile covered in 30 seconds to its credit. But even this marvellous performance pales before the velocity attained by an electric car in the Berlin-Zossen Railway, which has given a very startling proof of the possibilities of electric traction.

Two German engineers, Messrs. Rathenau and Schweiger, were travelling one night in a sleeping car between Berlin and Milan, when they began to discuss the subject of railway speeds. Before the discussion ended they had determined to carry out some practical tests. On their return home they looked about for financial support, which they found in the offers of Messrs. Siemens & Halske, the General Electric Company, numerous banks, manufacturers and scientists, and the War Minister to aid them in every way.

The German railroad authorities placed at the engineers' disposal the 14¼-mile stretch of military line between Marienfelde, near Berlin, and Zossen. The Siemens & Halske Company undertook the construction of the line, supplying the electric power; while the "G.E.C." guaranteed a sufficient amount of current from their electrical generating station at Oberschönweide, seven miles north-east of Marienfelde.

This line was, by virtue of the absence of all but the slightest curves and gradients, peculiarly suitable for the experiments. But the permanent way, with

its light rails, inferior sleepers, and poor ballasting, left much to be desired. The authorities therefore improved both sleepers and road-bed before commencing the tests, which in 1901 produced a speed of nearly 100 miles an hour.

The track was so badly knocked about by the passage of the cars, that during the summer of 1902 a new track was laid beside the old, having much heavier metals placed on fir sleepers and broken basalt. Seventeen metres of the total distance were equipped with guard rails, such as are used on ordinary railway bridges, laid inside the wheel rails, and at a distance of about 2 inches from them. Besides preventing derailment, they greatly strengthen the whole of the road-bed.

The current for these experiments was supplied at a pressure of about 15,000 volts from three copper wires carried on poles 7 feet from the middle of the track, and transmitted to the motors through six arms swinging on two upright masts attached to the car top, one at each end.

Two cars were used for the trials, the bodies being made by Messrs. van der Zypen & Charlier, and the motors coming from the works of the Siemens Halske and G.E.C. Each car carried four motors, each of 250 horse-power; was 68 feet long; accommodated fifty passengers; and weighed about 100 tons. The body of the car rests upon two six-wheeled trucks, the motors operating the two outside axles of each truck. The wheels are 4 feet in diameter, and are controlled by

Westinghouse air, hand, and electric brakes. The air brakes alone give a pressure of 150 tons on the wheel treads.

The Siemens car was first given a run on the new track. In September 1903 it attained 189 kilometres (112 miles) per hour. On October 6 the pace was improved to 201 kilometres (126 miles), to the great astonishment of the crowds of spectators. Over and over again eight minutes sufficed to cover the 14¼ miles from start to finish. The engineering world was still metaphorically electrified by this performance, when, on October 23, the same car broke its own record with a 207 kilometres (128½ miles) dash.

Meanwhile the G.E.C. car had been at work, and its driver coaxed it to 210 kilometres (130½ miles per hour), so eclipsing the feats of the other vehicle. Even at these terrific velocities there was very little vibration.

As the maximum authorised speed had now been reached the trials were concluded, though the engineers felt confident that another 12 miles an hour could be added without danger to track or rolling-stock.

One of the half-dozen persons who travelled in the car has recorded his experiences of a journey made at more than two miles a minute.

"I think," he says, "that I might fairly compare my own feelings at the start of my journey to those of a novice making a first balloon trip. Travelling at what seems an unnatural speed, we were largely facing a group of unknown dangers, just as in aerial flight.

Something unforeseen might happen, with consequences as frightful as anything that could befall an aeronaut; for collision, collapse, or derailment of a train travelling at over 100 miles an hour must have fearful consequences. Experimental as was the trip, who could be sure that somebody had not miscalculated something—the track, trolley wires, motors, any one of them might unexpectedly fail.

"Before starting on the trip I was reminded in a suggestive way that it was not absolutely unattended with risk. The idea was politely and kindly conveyed to me in the shape of a piece of paper. I was to be specially insured against death or injury in the event of an accident by the Deutsche Bank, in compliance with a formality of Prussian law.

"It was a novel experience, and, strange to say, as is generally the case when undergoing anything unusual afloat, ashore, or in the air, not one of us felt the slightest nervousness. The chief excitement experienced by myself and my fellow-travellers was in watching the meter record the changes in our speed, as it gradually grew faster and faster.

"The car is in shape not unlike a boat. At each end its windows meet in a point, forming as it were a nose to pierce the wall of air in front. At each end is a place for the motor man, who, by means of three wheels, a handle, and the brake, controls at will the enormous outside forces which make such a speed possible.

"The motor man slowly turned on the current of

14,000 volts, and the car began to move gradually forward. As it did so it made a humming noise, but we felt no kind of sensation or jerkiness, the motion being smoothness itself. Our first recorded speed was only forty-five miles, but in a little over a mile this had increased to sixty-eight, and then to eighty-five.

"Faster and faster, and we had reached a speed of 108 miles, when my sensations of rapid travel began in earnest. There was, of course, the old illusion of passing objects. Trees, buildings, posts, seemed to be rushing past us, and we ourselves to be stationary. All the time we felt a desire to go faster and faster. Even when travelling at 130 miles an hour we chafed that we moved so slowly. We had indeed, for a while, become speed-maniacs.

"Bewildering in the extreme were many of the sensations. Looking out through the front windows, I noticed with trepidation that we were approaching a bend in the line. So furious was our advance that I could not conceive that the train could possibly take the curve without derailment. A few seconds—every emotion was an affair of seconds or fractions of them—and I saw that my fright was laughable; the train glided around the curve with an easy grace, and the fear was past.

"Once we had attained our high speed we began to notice a strange, puzzling, musical sound—a continuous hum. Even my experienced fellow-travellers themselves could not exactly account for it, as it did

not come from any vibration of the machinery; but at length we found the solution. Our passage was so furious that stones, sand, dust—every movable object on the track whipped in dozens against the carriage with such rapidity as to give forth a continuous note. A rushing sound behind us came from nothing else than the fallen autumn leaves, which followed us in a cyclone.

"We were too excited to talk. Now and again a remark was made, but the speaker was generally frowned down. There was one exciting incident. Standing right in the track, some 800 yards away, were two men, who seemed to be quietly chatting, unconscious of the approaching monster. Our whistle shrieked, and they fortunately rushed away, but none too soon. For although they were half a mile distant, that does not mean safety in the case of such a train as ours. Little less marvellous than our speed in full flight was our pulling up—the brake was put on within 1000 yards of the journey's end. At first it was applied gradually, and then at its full force; although the current, too, had been switched off, yet the car slid into Zossen on its own momentum."[1]

It has been calculated that if the electricity were suddenly cut off when the car travelled at 130 miles per hour, it would have continued to progress for 17 miles. To make these figures more suggestive, the writer of the above account asks us to imagine a train from which the motive power has been suddenly removed

[1] *Pearson's Magazine.*

at Hatfield reaching King's Cross before coming to a standstill !

Considering the great advances made recently in electric traction, it will not be a matter for surprise if, in a few years, Rhodesia is traversed by some very fast electric trains. The transmission of power to a long distance is a comparatively easy matter nowadays; and in the Victoria Falls of the Zambesi Rhodesia has the grandest source of energy that the world can offer to man. The Falls plunge 400 feet into a zigzag chasm, over a lip one mile wide, so that even the immense power of Niagara itself is here completely dwarfed. By means of turbines the "smoke that sounds" will be partially converted into electric current to send cars spinning along the metals of the Rhodesian section of the Cape to Cairo line. To the native the relations between the flying car and the magnificent waterfall will for some years be hard to understand, though the passage of the telegraph line through his country has given him a glimmering of the mysterious ways of electricity.

CHAPTER XXI

THE RAILWAY MANIA

EVERY now and then a nation loses its head over financial matters, goes money-mad, and speculates wildly in a fashion that can have but one ending—the ending of a gambler.

We all know something of the famous South Sea Bubble, which in Queen Anne's reign ruined thousands of thrifty folk, and left behind it many a desolated home and suicide's grave. Hundred pound shares of the South Sea Company's stock changed hands for a thousand pounds or more. Then the reaction set in ; the shares fell in value with terrible rapidity, and soon were worth little more than the paper of the scrip. It took all Walpole's financial genius to save the credit of the nation from being lost amid the general catastrophe.

Even more disastrous in its consequences was the mania for buying and selling shares in existing or projected railways which twice seized the British public ; the first time in 1836, and again in the years 1843–45.

In the early thirties the railway had few friends. Those people who were not openly hostile to it, were either utterly indifferent to its development or cynical.

As a few years ago caricaturists heaped ridicule on the motor car—to-day a great power in the land—so then every comic draughtsman or scribbler must have his fling at the dangerous, noisy, smelly, illness-causing, ugly locomotive,—epithets which by no means exhaust the list of adjectives applied to the steam-horse.

But in spite of the jeering the faithful few persevered, and the despised railways soon began to pay dividends of 10 and even 15 per cent. In 1836 money was "easy," that is, plentiful, and profitable investments were hard to find. So that before long the railways attracted the attention of the financial world. People suddenly discovered that the earning of a good dividend covered a multitude of sins. The iron track, once everybody's butt, blossomed into "a great civilizer," "a priceless boon," "a triumph of peace," and so on, according to the command of language enjoyed by the journalist who rushed into print in praise of the new panacea for all evils social and political.

Folk tumbled over one another in their eagerness to buy scrip. The wildest schemes for new lines found immediate support. Nothing seemed too idiotic, when the public had for the time become a race of idiots; among whom only a few men, such as George Stephenson, managed to keep a cool head. Huge fortunes were made and lost in a week or two. Paupers became rich men; millionaires sank into poverty. Trickery and knavery of all sorts was rampant. The industrial balance of the country was

upset; and the year ended amid the gloom of acute monetary depression.

Yet the speculation of 1836 was but a mild gamble compared with that of the second period (1843–45). Once again people looked about for something which would yield a better return than Consols, now above par, and so scarcely worth buying. The mania "commenced in 1843, was continued in 1844, and arrived at its height in 1845, during which thousands of persons were ruined by the absurd rush for shares." Railway schemes grew with a mushroom growth. In January 1845 sixteen new lines were registered, and in the eleven months following, more than 1200 lines were projected, a very small proportion of which ever received Parliamentary powers. No part of the country was too barren, too remote, too poverty-stricken, too thinly populated, to be described by the projector as affording an opening for a most profitable line. In one place a railway was advocated because it would run over the route once taken by a Roman Road! In another district a sufficient cause was found in the fact that a Danish Invasion had once passed that way!

As during the cycle "mania" of a few years ago, everything and everybody connected with the cycle trade enjoyed a sudden "boom," so during the *furore* of 1843–45 did the railway press, the railway expert, even the individual who had the shallowest acquaintance with railway matters, find themselves inundated with business. A hundred newspapers sprang into

existence, reaped a great harvest out of the advertisements, which sometimes in a single journal amounted to £10,000 a week, and expired in a few months. Men who could draw, survey, or in any way make themselves useful to the promoter, received princely salaries ranging upwards to £10 a day. The most magnificent schemes were carried through—on paper. Extraordinary public boons were brought home to the railway—on paper. Writers excelled themselves in flights of imagination which saw the railway levelling all class distinctions, and replacing poverty and discontent by comfort and universal brotherly kindness among men. This, again, was only a matter of paper. Arguments were forthcoming to prove that, however much money was sunk in railways, it must eventually benefit the community by keeping the wealth of the nation "on the move." Lord Bacon's saying that "money is like muck, and does no good till it is spread," was adduced as a testimony to the advantages of pouring the wealth of the public into the pockets of the engineer and navvy, who now became familiar figures all over the country. The navvy, a much more uncouth person in those times than he is at present, caused consternation and often terror among the country folk with whom he came into contact. Cases of robbery and outrage were numerous, and the law, as represented by a few constables, was powerless to maintain order in the large camps of the navigators.

The surveyors also showed a sad lack of manners,

being attracted on the one hand by the rewards accruing from business successfully carried through, and encouraged on the other by the wealthy companies for whom they worked. Collecting bands of ruffians, they set the landowners at defiance, with the natural result that there were some very pretty scuffles, when the owners also organised a force to resist the invaders. A fair instance of such conflicts has already been given in the case of the Harborough Estate (pp. 24–25).

By 1845 the rage of speculation had become so acute that the police had often to be called in to regulate the crowds besieging the Stock Exchanges of London and other large cities. Amid the general rush for money the railway did, indeed, to some extent prove a leveller, for people of all classes jostled one another in their haste to purchase the scrip dangled temptingly before their eyes by this or that promoter. Vainly did sober journals, such as the *Times*, urge caution and self-control, prophesying the crash that must follow so unhealthy a growth of railway schemes. They might as well have asked a man dying of thirst to content himself with half a pint an hour when at last he falls in with a pool of clear, sweet water.

Meanwhile the Parliamentary horse was being worked to death. Five hundred and sixty-one Bills came before the Commons. Nearly three hundred of these were promptly slaughtered, and the rest received the Royal Assent. Finally the legislators' patience

gave out, and the Board of Trade fixed November 30, 1845, as the day by which all plans of further projected lines must be deposited.

Then ensued such a scene as cannot be paralleled in the history of finance. The boom was already showing signs of a break, and it became absolutely necessary for such schemes as should be saved from ruin to be given Parliamentary powers to commence work at once. November 30 happened to be a Sunday, and this led to some difficulties. Never was the first day of the week less a day of rest. At twelve o'clock the offices of the Board of Trade would be closed.

Promoters hired special trains, special coaches, or special relays of horses to bear their plans to the Metropolis. In some cases a railway refused to carry people interested in a scheme that might prove harmful to it, and all sorts of devices were resorted to to evade the officials. A story is told of a large roll of plans being placed in a coffin, which was taken to the station on a hearse, attended by mourners wearing all the outward signs of deep sorrow. The coffin, on reaching London, was driven straight to the Board of Trade Offices, where its contents found their last resting-place.

Post-boys were bribed to drive their fares astray, or pretend ignorance of the road. Wheels were loosened ; horses stolen. Scarcely a mean trick went unused. On the other hand, some very remarkable running occurred on the railways, as may be gathered

from the fact that one "plan-special" covered the 118 miles between Bristol and London in an hour and a half at an average speed of nearly eighty miles an hour!

Of course, many plans arrived too late, and the bearers, driven to desperation, hurled them in through the windows, from which they were as speedily ejected.

Then came the crash. Prices fell by leaps and bounds. Everybody wished to sell, nobody to buy. Thousands found themselves penniless, and trade so bad that many avenues of earning even a pittance were closed against them. Some resorted to suicide, the final act of despair, and an even greater number languished in prison until their debts should be paid. The battle had been much severer even than that of the parties who strove during the South Sea Bubble, and the dead and wounded were proportionately more numerous.

Among the speculators of those wild days no one could vie with the "Railway King," as George Hudson was named. He may be called the Napoleon of the mania, for although he outgeneralled his opponents, won many brilliant victories, and had the financial world at his feet, he eventually found his Waterloo. It must be placed to his credit that even if, after the manner of conquerors, he caused a great deal of misery, he did some really good work in the cause of railway extension, notably as regards the Midland system, of which he was the first Chairman.

Born in 1800, he began life as a linen-draper's assistant in York. When thirty-two years old he had attracted notice on the Board of Health of his town, and in 1837 was elected Lord Mayor. Two years later he took a prominent part in the opening of the York and North Midland Railway, which owed its existence largely to his perseverance and business capacity. In 1842 he was appointed Chairman of the North Midland Railway, and in 1844, when that line amalgamated with the Midland Counties and Birmingham and Derby Junction, he accepted the chairmanship of the joint concern.

During the mania Mr. Hudson fought a fierce Parliamentary battle on behalf of the Midland against the proposed London and York scheme. As a fighter he was seen at his best,—cool, untiring, cheerful. When once he took a project in hand he devoted his whole energy to it until he emerged victorious, or knew that the cause was hopelessly lost. As a consequence he was much sought after as a director by companies outside his own. His word became law. A few strokes of his pen carried as much weight as an Act of Parliament. He had an interest in practically every railway between Edinburgh and London. He "plunged" magnificently, buying by the hundred thousand pounds where other men were content to invest or risk their thousands. At one time he controlled over 1000 miles of railway. He became a popular hero; was cheered wherever he went; and, in addition to two re-elections to the York Mayor-

alty, was returned by Sunderland as its Member of Parliament.

Whether intentionally or not, Hudson became involved in transactions that savoured of fraud, and in 1846, at a meeting of the Midland Board called for the purpose of deciding whether they should buy up the Leeds and Bradford line recently opened, he was openly accused of consulting his own interests rather than those of the shareholders whom he represented: because, as Chairman of the Leeds and Bradford, he had advocated the purchase of that line by the Midland. Though he apparently cleared himself from the charges of misappropriation, his reputation had received a blow from which it never recovered.

The "Railway King" now fell on evil times. He whom the Prince Consort had once asked to be introduced to him, became the target at which every caricaturist launched his shaft. It was vain for him to state: "It has been my good or bad fortune to be the purchaser of many railways; and I might frequently have taken advantage of my position and knowledge to go into the market and lay out large sums with great benefit to myself, but I publicly declare that I have not done so, and call upon any person who can prove anything to the contrary to come forward and do it at once." Satirists delighted to recall his draper days, and represented him sitting in his shop; at the mouth of a tunnel learning "how a great deal of railway business may be kept in the dark"; or seated in spider shape at the centre of a

huge railway web to catch the shareholders for whom he had spun the meshes. Last scene of all, George Hudson, alone and deserted on a platform, vainly trying to stop the train which was leaving him in the lurch.

At an extraordinary meeting of the Midland shareholders held at Derby, April 19, 1849, Mr. Hudson, in a letter of considerable length, stated: "After due deliberation I have thought it right and to be more satisfactory to the shareholders of the Midland Railway Company to resign the office of chairman." The thousand proprietors there assembled also found his action most satisfactory, and his connection with the Midland was thus severed. He had undoubtedly been playing a double game which an honourable man could not have reconciled with his conscience. He had, while professing undivided loyalty to the Midland, taken a share in obtaining Parliamentary sanction for a short line which, by connecting the Great Northern with the Manchester and Leeds Railway, deflected on to the metals of the former company a large amount of traffic hitherto handled by the Midland. When this was discovered—after his resignation—the shareholders naturally maintained that he had betrayed their interests, and demanded a committee of inquiry. In 1853 judgment was given against him in the Rolls Court, requiring him to account for various blocks of shares which he had appropriated, as well as for those with which influential members of Parliament had been bribed

to aid the passage of Bills introduced by him. After that every board-room was closed against him; and though Sunderland re-elected him till 1859, his power had departed, and he took himself off to the Continent, there to indulge, on a smaller scale, in schemes such as had won him notoriety in England.

Till the last he retained his self-confidence, and paraded his unjust treatment—as he deemed it—at the hands of those whom he had served. He was lucky to have friends who stuck to him through evil as well as good report, and by generous gifts saved him from the fate which overtakes the majority of fallen men—to die poverty-stricken in a wretched garret.

This brief account of the man to whose piping the railways of England danced for nearly a couple of decades may fitly be closed with the words of Mr. Clement E. Stretton, who says: "The greatness of Hudson's railway genius only makes it all the more lamentable that so great a man should have so deplorably fallen and have been guilty of acts which resulted in ruin and universal condemnation."[1]

[1] "The History of the Midland Railway," p. 268.

CHAPTER XXII

THE GRAIN ELEVATOR, THE RAILWAY AND THE WORLD'S FOOD SUPPLY

It has been said that the opening of the Canadian Pacific Railway aimed a more deadly blow at the prosperity of English agriculture than it had yet received. At first sight the connection between the Canadian highway and Farmer Hayseed may appear obscure, but a little consideration will show that in a world where the balance of trade is easily upset, the sudden entry of the virgin lands of Manitoba, Assiniboia and Alberta into competition with the broad acres of Old England could not but have a very adverse effect on English farming. On the one hand we see an almost boundless expanse of open prairie, cheaply bought, easily tilled: on the other, cramped fields, high rents, and a need for the constant enriching of the soil. While the English farmer is compelled to turn his plough or other gear about every few hundred yards, his Canadian brother can drive his mower or harvester a mile or more right ahead, and employ machinery which cannot do itself justice within the limits of a ten-acre field.

But however plentifully the Canadian plains may yield their crops of grain, the grain itself would be to

a large extent useless did there not exist some means of conveying it to the millions of mouths awaiting it outside Canada. It is the railway that in the Dominion, as elsewhere, plays so important a part in the distribution of the world's food. Were the railways suddenly spirited away by some evil genie, we should soon find ourselves on the verge of starvation: though at a distance thousands upon thousands of tons of grain would be rotting for want of a consumer.

In conjunction with the steamship, the locomotive has proved one of the greatest benefactors of mankind. Famines, where not rendered an impossibility, are at least greatly mitigated by the speed with which the lands that have can transmit their surplus to the lands that have not; pitching it into waggons, which fly hundreds of miles to the sea-coast and transfer their cargoes to ships, to be delivered back at the voyage end to the railway for final distribution. One of the most remarkable features of the recent Indian famines was the celerity with which food of various kinds poured into the stricken provinces from distant regions.

The loaf that graces your breakfast table may be made of wheat that once waved in Canada, Dakota, Texas, Chile, Argentina, Egypt, Russia, France or India. The chances are greatly against its being of British origin. If that loaf could speak, it might tell you a very interesting story; but being dumb, let its tale be narrated by the proxy of pen and ink—a tale so closely bound up with that of the iron horse as to be fitly included in an account of steam locomotion.

We will go straight to the greatest corn growing country of all, the United States, where a bountiful nature, working hand in hand with the latest inventions of agricultural science, produces yearly nearly a thousand million bushels of wheat, in addition to two and a half times that quantity of maize, and enormous weights of barley, oats, rye, and buckwheat. Out in North and South Dakota, Nebraska and Kansas, flourish the "bonanza" wheat farms, covering each six or seven square miles. These gigantic wheat-fields have developed from the free grants given years ago by Government to the railway companies as an encouragement to push their metals from east to west of the continent. For convenience' sake the land was sold in very large blocks, now often the property of a single man, who has imported the newest machinery and conducts operations on a scale that is quite unknown to the English yeoman. The owner often does not reside on his land, but entrusts its management to an overseer, who thoroughly understands the nature of the soil, and bears the whole responsibility of sowing and gathering in the crops. Everything about these farms is large. The stables can house 160 horses; the barns hold 500 or more tons of hay; the reaping and other machines may be counted by the score; and each machine may require the force of twenty horses for its propulsion.

On such spacious properties, often situated in districts where "hands" cannot easily be got, machinery takes the place of human labour to an extent scarcely

equalled in any other part of the world. The ploughing is done by "gang" ploughs, capable of turning over four to six acres of soil a day, since the season when such work can be performed is short. In the spring huge harrows are used to pulverise the soil for a width of 25 feet (compare this with the 6 or 7 feet of English practice), at a rate of perhaps 100 acres per diem. One man can attend to a single harrow.

Sowing is conducted with four-horse drills whose progress, on a windy day, is marked by a dense dust-cloud, often obscuring men, horses and machine.

Sowing finished, the sun and rain are left to do their work till the harvest approaches. The first signs of ripening send the overseer to the nearest town, where he buys the available labour at rates which in another country would appear princely. As soon as the men are hired the self-binding reapers come forth from their resting-places for another period of activity. It is no uncommon sight to see twenty or more of these wonderfully ingenious machines following one another round a huge grain field, into which they eat many yards every circuit. The sheaves, ready bound, pour from their collecting-boards, and are arranged in stooks by skilful workers, who set them so firmly that a high wind can hardly affect them.

The threshing-engine now has its turn, moving from place to place, in order to save, as far as possible, the labour of transporting the sheaves which are hurried into the maw of the buzzing drums. The straw, so much valued in some countries, is here

either used as fuel or collected into huge piles and burned. One of the most extraordinary machines in the world is the combined header and thresher, propelled by two or three dozen horses. It cuts a swathe 50 feet wide, just removing the heads from the stalks, threshes out the corn as it moves, separates the chaff from the wheat, and delivers the grain, duly weighed, into sacks. Sometimes the horses are replaced by a gigantic traction-engine, moving on wheels 5 or 6 feet wide, so that it may not sink into the earth. This Juggernaut will "sack" a hundred acres of wheat in a dozen hours. It can, however, be used only in regions such as California, where a rainfall is a very rare occurrence, and the wheat gets "dead ripe" without shelling-out.

The clean grain is dumped into waggons and hauled to an "elevator" at a railroad station. The farmer has not to go into open market with his samples and sell his crop for the best price he can get. He merely takes it to the nearest elevator, capable of holding 10,000 to 50,000 bushels—the property of some individual or company dealing in grain. The prices vary from day to day like those of stocks and shares, and the farmer delivers his grain when he thinks it will stand at a good figure. His whole crop is transferred from the waggons to the elevator, and a cheque is given him for its full value. Then his part of the business is at an end. The grain business, therefore, much resembles the oil trade of Pennsylvania, West Virginia, and Ohio. Individual wells are connected

by small pipes to the trunk lines operated by companies. The owner of a well turns, say, 10,000 barrels from his own reservoir into these trunk lines, which run for hundreds of miles to a seaport. He obtains a receipt, which is negotiable like an ordinary cheque.[1]

The wheat accumulates in the elevator until the latter is full, and must be emptied into cars, which remove it to elevators of far larger dimensions at Chicago, Duluth, or Buffalo, on the Great Lakes, or to some seaport. The Chicago elevators alone can hold between them nearly 30,000,000 bushels.

The elevator is the outcome of the need for being able to cope with an increase in the corn yield of a season. While the farmer wishes to get his crop off his hands as soon as possible, the middleman to whom he sells it may be compelled by the state of prices to hold his purchase so as to avoid "glutting" the market. Only a fraction of the total crop of the United States is consumed at home, and the balance must be retained in stock till the crops of other countries can be estimated. Then the prices become steady, and the grain companies begin to sell, watching any chance of a rise.

There are two varieties of elevator: the receiving house, or store-house, and the transfer house. "The first-named structures are located on shore, but at cities on the American Great Lakes and along the Atlantic seaboard can be found floating elevators,

[1] See "Romance of Modern Engineering," p. 360 foll., for an account of the American oil-fields.

by which the contents of the lighter or canal boat are discharged into the hold of the ship. The transfer elevators are usually located at the waterside, as they are intended for moving grain from vessel to car, and *vice versâ*. If they are marine elevators the plans provide for running the grain cars directly into the structure, tracks being laid along the ground floor of the building. If the location is such that this plan is impracticable, the track is laid along the side, and from openings in the buildings project the receiving legs, or spouts, which are from 15 to 25 feet in length, and hinged, so that they can be hoisted against the side of the building when not in use. The end of the spout is carried into the car by the feeder, who moves it from place to place as the contents of the car are emptied. With the spouts in modern use all of the grain, with the exception of a few shovelsful, can be taken out, so that the only manual labour required is that of the feeder. As an ordinary leg will elevate from 9000 to 10,000 bushels an hour, a trainload of 30 or 40 cars, representing 1500 tons, can be passed into the building in this time if it have the average number of receiving spouts."[1]

The nature, then, of a transfer elevator is merely that of a machine for shifting grain from one place to another. The storage elevator takes upon it the function of the houses built by Joseph in which to amass wheat against the coming famine. The largest specimen stands at West Superior, Wisconsin; it can hold over three million bushels. Owing to the

[1] "The Engineering Magazine," May 1902.

immense weight carried by such structures, they are based upon a very thick foundation of concrete. To accommodate the grain great metal cylinders, eighty to ninety feet long, are reared on end, side by side, and enclosed with a wall of stone or brick. These bins are of varying capacity, the largest ranging to 25,000 bushels. Above the bins is the distributing floor ; above that the scale room ; above that again the cleaning garners ; and on the top of all rises the power floor.

When a train-load of grain arrives at the elevator a conveyor is let down into the cars in succession. This may be either an endless belt of buckets which fill and discharge automatically as the belt moves, or a wood or metal conduit from which the air is partially exhausted by means of a fan so as to produce a powerful suction. On arriving at the top of the elevator, the grain passes through sieves, which remove foreign matter. It then flows to the next floor, where are a number of weighing bins. As soon as a certain amount—10,000 to 15,000 bushels—of grain has entered a bin, a door opens in the bottom and the contents are shot into a storage bin, or out of the building into a vessel, as the case may be.

From the storage bins the grain is delivered to a ship by spouts of much larger capacity than the receiving spouts, working separately or in unison. Four of these spouts will transfer 100,000 bushels in an hour.

In some places liable to inundation by a sudden rise of the river or sea adjacent, the elevator must be built some way back from the water's edge. The delivery spout is then replaced by belt conveyors

spanning 500 to 1000 feet, which run through covered belt galleries to a wharf at which vessels can tie up. In the most up-to-date structures electricity plays an important part as the motive power by which all the running gear is worked.

Externally, the elevator is anything but picturesque. Its tall, slab sides rise a couple of hundred feet, without any pretence of ornamentation. So lofty are these buildings that they dominate all their surroundings.

But they are most useful, and to them is due to no small extent the cheapness of the wheat which we convert into the "staff of life," since they save a large amount of labour that otherwise would be expended on handling the grain.

We thus see that from the moment that a grain of wheat is placed in the sowing drill to the time when it reaches the consumer, it is scarcely, if at all, touched by human hand. Machinery puts it in the earth; machinery gathers, threshes, cleans, weighs, transports, and grinds its offspring. In large bread factories the dough is mixed and conveyed to the oven by machinery. And very possibly the first occasion on which a finger touches it is its removal to the baker's cart for delivery to his customers.

Returning to the railway in our last sentence, we may claim a great advantage over Joseph's brethren. When they needed corn they were compelled to go to fetch it: when we need corn it comes to us. Consequently the human race as a whole is much better off now than it was in the time of the Pharaohs.

CHAPTER XXIII

ADVENTURES ON THE LINE

THE Uganda railway runs from the Island of Mombasa on the east coast of Africa to Port Florence, 580 miles distant, on the eastern shore of the great Victoria Nyanza. In the five years following 1891 the surveyors were busy marking out the best route for the line which the British Government built to open up trade between the central districts of the British East Africa Company and the Indian Ocean—a task by no means easy in a country infested by wild beasts, badly watered in parts, and beset with dense, prickly jungles which presented a hedgehog-like front to the explorer.

However, the survey came to its desired end, and in 1895 operations commenced at the eastern end. By 1897 railhead had reached a point over 100 miles from the coast, named Tsavo. Lieutenant-Colonel J. H. Patterson, D.S.O., was sent out in that year to take command of the army of Indian navvies who had their camp at the place mentioned—now a little way-side station.

In 1898 the navvies suddenly became the quarry of a couple of fierce man-eating lions, whose depredations spread such panic among the poor fellows that for a time work on the line was disorganised and actually

suspended. Lord Salisbury, speaking in the House of Lords about the progress of the Uganda Railway, said: "The whole of the work was put a stop to for three weeks because a party of man-eating lions appeared in the locality and conceived a most unfortunate taste for our porters. At last the labourers entirely declined to go on unless they were guarded by an iron entrenchment. Of course it is difficult to work a railway under these conditions, and until we found an enthusiastic sportsman to get rid of these lions our enterprise was seriously hindered."

The sportsman in question was Lieut.-Colonel Patterson himself, who has, in the pages of the *Wide World Magazine*, given a detailed account of the depredations of these savage beasts, and the manner in which they were eventually brought to book. The story is so interesting, and its authenticity so well established, that a few pages may well be devoted to its more striking episodes.

Scarcely had the coolies settled down at Tsavo, when one or two of their number disappeared mysteriously. At first it was thought that they had been done away with by their fellows or some prowling natives. News soon went round the camp, however, that a Sikh had been seized by a lion while sleeping with a number of companions in a tent, and carried off into the bush. After that the tent doors were kept vigorously closed; and Colonel Patterson commenced his long and patient series of night watches for the enemy.

His post was usually in a tree, whence, night after night, he could hear the roarings of the lions as they

approached the encampment. As soon as their hunting began they became perfectly silent; and presently there would be a shriek heard, to prove that one more luckless coolie had gone to swell the total of victims.

The lions displayed the greatest cunning, visiting different parts of the lines each night, so that no one knew where to expect them. To track them into the bush would have been a very risky proceeding, and there appeared to be no remedy, except to wait until chance should bring the brutes within rifle-shot.

Their success made the lions bolder. Of flames they recked nothing, and they bore off more than one man as he sat close to the blaze of the camp fire. Accordingly, the camp was surrounded with a *boma*, or artificial hedge of thorns. The lions leaped over it, and even invaded the hospital tents, killing one man and wounding two more on their first visit. It became necessary to remove the hospital to a position nearer headquarters.

About this time the main body of the coolies, numbering between 2000 and 3000 men, left Tsavo and migrated to the new railhead, some miles away. The few hundreds left behind, feeling that their individual chances of proving the next victim had materially increased, grew more and more nervous.

A cruel fate now overtook the water-carrier of the hospital. "The *bhisti*," says Colonel Patterson, "was lying on the floor of his tent, with his head towards the middle and his feet touching the side. The lion put his head under the canvas, seized him by the foot, and dragged him out. The poor fellow, in despera-

tion, clutched at a box, which he dragged with him until it was stopped by the tent, and he was forced to let it go. He then caught a tent rope, which he held tightly until it broke. As soon as the lion got him clear he sprang at the man's throat, and the poor water-carrier's cries were silenced for ever. The lion, not being able to leap the fence, ran up and down with his lifeless burden in his mouth, looking for a weak place to force his way through. This he presently found and plunged into, dragging his victim with him, leaving shreds of torn cloth on the thorns as evidences of his passage."

Colonel Patterson at once had the hospital moved again, and, hoping that the man-eaters would try their luck a second time in the same spot, hid himself with Dr. Brock in a covered goods waggon on a railway siding close by. The top part of the doors was kept open, so that the watchers might have a chance of seeing what went on outside. Presently a twig cracked close by, and Colonel Patterson suggested that he should go out to reconnoitre. At his companion's advice he remained inside, fortunately for him, as the lion was actually stalking the ambush. Presently "a huge body sprang at us. 'The lion!' I shouted, and we both fired almost simultaneously, and not a moment too soon, for before he could turn I felt his hot breath on my face." But the brute escaped with a whole skin; and though for a time he and his mate ceased their marauding, it was not very long before they had sufficiently recovered from their fright to take the field again with renewed activity. In a week

five men were carried off and eaten. The Chief therefore decided to construct a trap out of sleepers and rails, and to bait it with a few men. For the protection of the latter the trap was divided into two parts, separated by a grid of rails. In its general principles this device copied the "catch-'em-alive-O" rat cage. Whether the lions suspected something wrong or not, at least they abandoned Tsavo for a few months; and when the coolies had grown used to their absence, returned, seized a man, and ate him within a few yards of his tent. On one occasion, while the chief was keeping his solitary guard, rifle in hand, he heard a purring noise, which told that the lions were having a meal close by. But the darkness made it useless to venture a shot.

Waxing yet bolder, the lions now delivered a double attack, sprang over the *boma*, seized each a Swahili porter, and dragged him off through the thorn fence. This proved quite too much for the coolies' nerves. On December 1, 1898, they all struck work, and declared that Tsavo had become too dangerous for them. "They had come from India on an agreement to work for the Government, but not to supply food for devils." It must here be mentioned that these superstitious fellows regarded the lions as the embodied spirits of chiefs who had once ruled in the land now intersected by the railways, and thus wreaked vengeance on the intruders.

Some hundreds of them were as good as their word, and swarmed on to the next passing train. Those who remained behind made themselves sleeping places

in trees, on roofs, on girders—anywhere except on Mother Earth.

Colonel Patterson, to whom the business of lying-out had long grown wearisome and distasteful, summoned the District Commissioner and as many soldiers as he could spare to take part in an organised hunt. Mr. Whitehead arrived at Tsavo after dusk, and while on his way to headquarters, in company with a native sergeant, he was attacked by one of the brutes for which he had come to look. The report of his carbine saved him from anything worse than some severe scratches; but the lion, not wishing to go hungry away, grabbed the unfortunate sergeant and made a meal off him.

Shortly afterwards a lion investigated the trap and was caught. The coolies, anxious to be quits with their ancient enemy, fired so randomly through the bars at him that they managed to blow away part of the door, and he escaped again, much to the annoyance of everybody concerned!

Luck was indeed on the side of the lions. A less keen sportsman than Colonel Patterson might well have despaired of ever getting even with the marauders. When at last he had a fair chance of finishing one of them off, the rifle—a borrowed one—missed fire, and so confirmed the Indians in their belief that they had to deal with something more than mere lions. However, all comes to him who waits. One night the Chief's rifle spoke to good effect, and next morning a man-eater was found dead, in the attitude of one about to spring. The natives could

not restrain their delight. They beat tom-toms, blew horns, seized their deliverer and carried him shoulder-high round and round the spoil, which measured 9 feet 8 inches from tip to tip, and stood 45 inches at the shoulder.

The other lion, in spite of its loss, maintained a formidable reputation; but his end also was not far off. As the result of a midnight feast on goats he received the contents of a double-barrelled smooth-bore; which for ten days or so put him out of action. Then he resumed his old tactics, killing goats where he could not get men. One bright moon-lit night the Colonel was at his usual post in a tree, when he saw the lion sneaking from bush to bush, taking advantage of every patch of cover in a most skilful manner. A bullet fired at close quarters struck the brute on the chest, and he bounded off into the woods, his retreat hastened by three additional shots, one of which also took effect.

At dawn trackers got to work, and, guided by blood marks, they soon came upon their quarry in among some bushes. Patterson fired at his head; the lion charged, to receive another bullet in his hind-legs. A third bullet apparently killed him, for he turned over and lay quite still; but there was enough life left in him for another rush, during which his evil career terminated. The workmen, burning with recollections of murdered messmates, could hardly be restrained from tearing to pieces after death the monster whom in his life they had so much feared.

As soon as the news of the second "devil's" death

was spread about, many coolies returned to the camp, whence they had been driven by their dread of the man-eaters. It must be said of the Indians that, if not over-brave men, they were at least appreciative, for they clubbed together and bought their deliverer a fine silver bowl, on which was engraved a Hindustani poem setting forth his prowess, trials and final triumph. This bowl is now to be seen in the Norwich Museum, flanked by the heads of the two prowlers that once made life so exciting in Tsavo.

Some time after the death of the second lion, Colonel Patterson stumbled on the den in which the pair lived. "It was a dark and fearsome cave, running under some enormous rocks, with a great tree growing near its entrance. It extended a good way back, and I did not feel inclined to explore it. The smell of the place was terrible. There were human bones lying about and also some copper bangles, such as the native of Africa loves to wear."

This is the story of the man-eaters, who were responsible for the death of twenty-eight Indian coolies and an indefinite number of African natives. It was indeed fortunate for the progress of the line that the bad example set by the Tsavo lions did not encourage others to imitation; and we may speculate on the outcome of a determined resistance by the brute creation to the advance of the engineer. As in this case, human cunning would, no doubt, have ultimately proved more than a match for that of the king of the beasts; but not until a terrible toll had been taken of the human invaders.

CHAPTER XXIV

OCEAN FERRIES

ONE day, in the year 1800, the Admiralty Board assembled to discuss a memorial addressed to them by a Mr. Henry Bell. It asked "My Lords" to seriously consider "the practicability and utility of steam as a marine-propelling power against winds and tides, and every obstruction in rivers and seas where there was a depth of water."

The gentlemen in question turned a deaf ear to the claims put forward by "the Father of Steam Navigation" in favour of the motive force that was so soon to revolutionise locomotion on both land and sea; all except England's greatest sailor, who, with a broad-mindedness and sagacity that did him honour, rose and said: "My Lords and gentlemen, if you do not adopt Mr. Bell's scheme other nations will, and in the end vex every vein of this empire."

These were indeed extraordinary words from the mouth of a man who had won fame by his handling of the sail-driven "wooden walls" of old England! Well would it have been for his country had future admirals showed as liberal a spirit in their criticism of new inventions. But even he must have only very dimly foreseen the day when huge armour-clad float-

ing forts should cut through the ocean at a speed compared with which the performances of his swiftest frigates were but a crawl.

Mighty as have been the influences of steam on the development of naval warfare, yet more wonderful must we consider the impetus given by it to the extension of trade and intercourse between nations. It is impossible to-day to realise the slowness and uncertainty of a passage between the far sundered parts of the world, when men relied on the humours of the winds and a journey to Australia might occupy six months or a year according to the condition of the elements. Now the steamship runs "on time" with the punctuality of an express train, and enables the traveller to circle the world without any vexatious delays.

The intimate nature of the connection between the railway and the steamship is too obvious to require any elaboration. The "boat train" and the "mail" which whirl passengers and postal matter to our great ports are our crack expresses. But they form but a part, and that not a very large one, of the great system whereby land and marine transport mutually feed and sustain one another. It is the cargo-carrying capacity of a ship that, as a general rule, renders its travels profitable to the owners. The splendid accommodation made for the comfort of passengers attracts the eye; but "the gintleman that pays the rint" has been carefully stowed by the thousand tons in the bowels of the mighty ship before the human load is

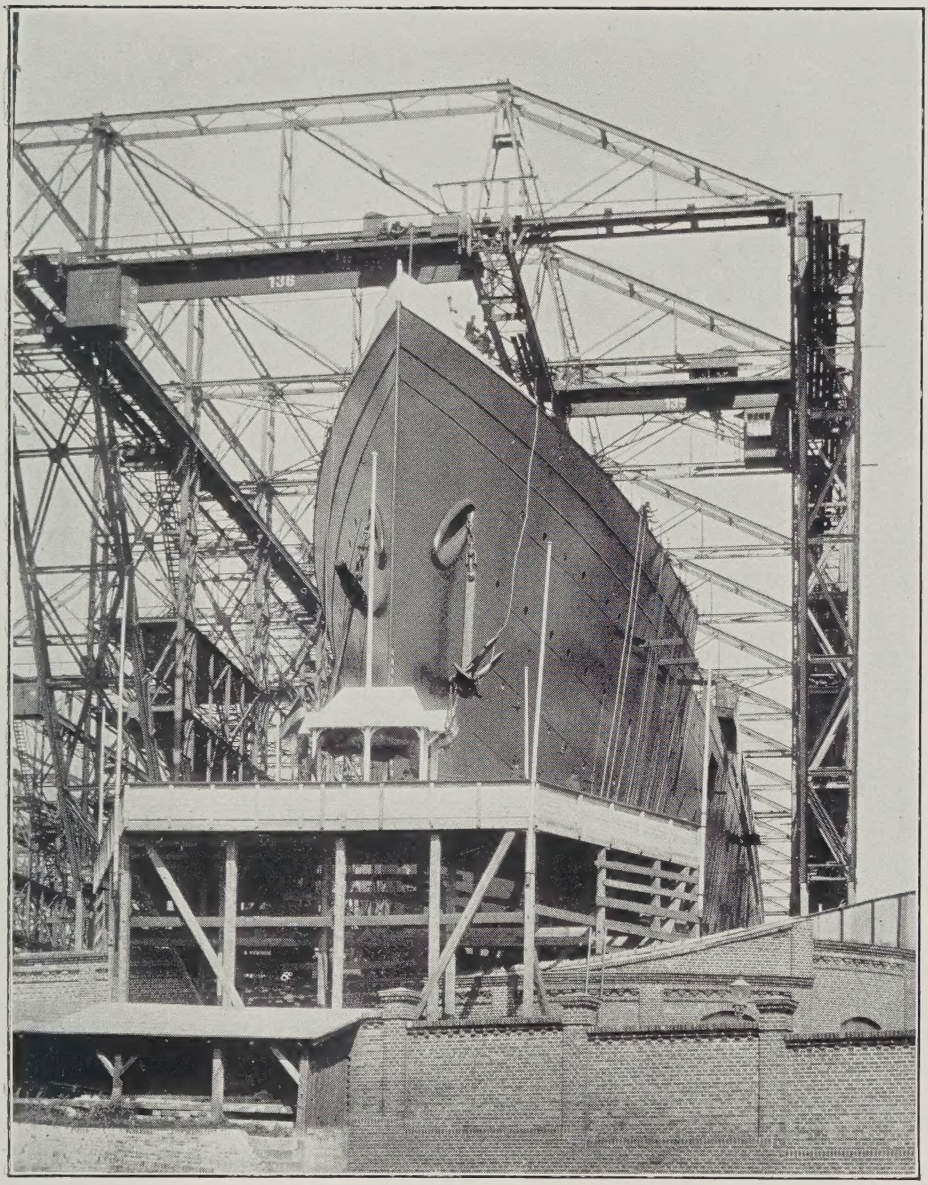
taken aboard. When the latter has landed and dispersed its several ways, the hatches are opened and mountains of merchandise soon accumulate on the quays and in the great warehouses that form so prominent a feature of a seaport: and long after the express has started on its course for the metropolis the contents of the lines are transferred to the slower goods train for distribution. This process generally escapes the eye of the globe-trotter, but it forms the life-blood of commerce.

It is interesting to note that the successes of George Stephenson on the railway gave a great impulse to steam navigation. The first steamboat was that of John Fitch, who, in 1787, propelled a boat on the Delaware River with paddles driven by steam. The pressure used in this and many subsequent boats was very low. Even as late as 1840 the Cunarder *Britannia*, of 2050 tons displacement, was run with but 12 lbs. showing on the steam-gauge. Stephenson, however, advocated much higher stresses, and the figures gradually rose till 1869, when the Inman liner, the *City of Paris*, carried boilers which raised 30 lbs. During the next two years a great advance was made to 65 lbs., and the era of compound engines on steamboats began. By 1886 a pressure of 150 lbs. to the square inch caused the introduction of triple expansion engines, and since then a further increase to 220 lbs. has enabled the engineer to use quadruply-expanded steam. It is indeed amusing to contrast the powerful boilers of to-day with those of the *Britannia*,

which were so gentle that when, on one occasion, a steam-pipe burst, the engineers "lapped it with canvas and rope-yarn"!

The story of the steamship is so full of such contrasts that we may briefly notice the main incidents which inaugurated the important periods of construction. The year 1843 deserves our special attention, since it saw the first employment of iron in a large ocean-going steamer—the *Great Britain*, built under the superintendence of Brunel the younger. This ship is also remarkable from the fact that it differed from previously constructed liners in the substitution of a screw for the usual paddle-wheels as the propelling power. The innovation at first caused some alarm among the men who tended the engines, since the number of revolutions per minute, which for paddles stood at 14 to 18, suddenly increased to 40 to 90, and it was feared that the machinery must fly to pieces under the strain. People watched with interest the performances of competing paddle and screw ships. For some time victory lay with the former, but gradually the screw ousted its rival. In 1881 the first twin-screw vessel, the *Notting Hill*, appeared. Since that date few liners have been constructed to carry but a single propeller.

Iron is no longer used for shipbuilding. Steel has taken its place, as being tougher and stiffer, weight for weight. But since even the stoutest metal cannot withstand the effects of a collision, security against sinking is further secured through the division of a



The Kaiser Wilhelm II. (before the Launch).

The largest mail steamer in the world ; 706 ft. 6 in. long, and propelled by engines giving 40,000 horse-power, and a speed of nearly 24 knots.

[*To face p.* 362.

vessel into a number of departments by a system of bulkheads. When the exterior walls of such a compartment have been breached a danger signal is given, and in a few seconds the doors in the bulkheads are closed, shutting off each compartment from its neighbours, so that, even if one or more are filled, the vessel will still have sufficient buoyancy to enable her to progress without risk.

SPEED.—As in the case of the railway, the increase of speed is one standard by which the progress of ocean travel must be judged. Disregarding the earliest experiments, we will commence comparisons in 1840, when the *Britannic* averaged $8\frac{1}{4}$ knots between England and America. A decade later the *Arctic* averaged $11\frac{3}{4}$, and in 1858 the *Great Eastern* 13. The "compound" *Oceanic* reached $14\frac{3}{4}$ in 1871, and the *Britannic* 16 in 1874. Twenty knots an hour were first covered by the *City of Paris*, 1889. During the years 1901–1903 records were frequently broken. In June 1901 the *Deutschland* averaged 23.51 knots between New York and Plymouth, which represents twenty-seven miles an hour, or a considerably faster speed than that of the Calcutta-Bombay expresses. The following year the *Kronprinz Wilhelm* managed to attain a mean of 23.37 knots over the same route. On the westward trip the former vessel also secured first place by a 23.15-knot voyage in September 1903. So that for the present the German liners have held the palm easily; the best English record being that of the *Lucania*, 22.01 knots.

The Cunard Company expect, however, to bring the record back to England when their new "flyers" get to work. This Company has received assistance from the Government in the shape of a sum of £2,600,000, advanced for the building of two huge vessels which shall have a *minimum* speed of 24½ knots an hour in moderate weather, so exceeding the finest efforts of the German greyhounds by a full knot. The money will be advanced in instalments as the work proceeds, and must be repaid in twenty years' time.

To propel these ships, which will measure 770–780 feet from stem to stern, at the contract speed, engines of 55,000 horse-power will be needed. They will, therefore, take first place at once for size, speed, and power. Apart from these considerations, they are of particular interest, since in them the turbine will replace the ordinary reciprocating engines. A committee of experts, who were appointed to decide the knotty point of turbine or rotary, recommended that the new steamers should be propelled by turbine engines; and the Cunard Directorate, with their usual enterprise, have agreed to the employment of turbines. It is only nine years or so since the *Turbinia*, of 44½ tons displacement, astonished the world by attaining a speed of 34½ knots (39.7 miles) per hour. Subsequently the ill-fated *Viper* and *Cobra* torpedo destroyers were built, and covered 41 miles in an hour. The turbine was then applied to the Clyde passenger steamers *King Edward* and *Queen Alexandra;* to the

Queen for the Dover-Calais route, and the *Brighton* for the Newhaven-Dieppe passage. These can all attain about 20 knots, and have proved very seaworthy and free from vibration. While cross-channel and coastwise turbine steamers are becoming quite common, the Allan Line has launched a Transatlantic turbine vessel, the *Victorian*, of 12,000 tons, for mail, passenger, and cargo traffic between Liverpool and Canadian ports. She, like the future Cunarders, will be the largest as well as the fastest of the fleet. She is fitted in the modern style for upwards of 1500 passengers, and it is expected that the absence of the throbbing movement, inseparable from even the best balanced reciprocating engine, will make her at once noiseless and particularly steady in a heavy seaway. A special arrangement has been devised by the Hon. A. C. Parsons, the patentee of the marine turbine, whereby a reversing power equal to that of the forward propelling power can be imparted to the machinery, securing almost instant arrest of the ship's forward motion, and very speedy backing in case of need. Hitherto the reversing of a turbine-driven vessel has been accomplished only by the use of special turbines, giving the turbine in this respect an inferiority to the ordinary type of engine.

To the engineer the adoption of rotary engines means increased speed for the same boiler power, due to reduced weight of machinery and increased economy in steam. The cost of upkeep is also less, while there is a smaller engine-room staff, and a

diminished bill for lubricants. To the passenger it means a complete freedom from vibration, and consequently much greater comfort. In short, the mere fact that the Cunard Directorate have adopted, on the best expert advice, the steam turbine, is proof positive that the rotary engine is the marine engine of the future, and its adoption will mark the commencement of a new era in navigation.[1]

The largest and, in many respects, the finest vessel afloat is the White Star liner *Baltic*, which has recently been launched from the yards of Messrs. Harland & Wolff, of Belfast. This leviathan is 725¾ feet long, 75 feet broad, and 49 feet deep. Her gross tonnage figures at nearly 24,000, and at the load-line she displaces about 48,000 tons, 28,000 of which are represented by cargo. The luxurious accommodation of the Atlantic liners is proverbial, and need not be mentioned here; but we may note that on the *Baltic*, and her sister ships the *Cedric* and *Celtic*, the passenger is much less liable to *mal de mer* than he or she is on smaller vessels. A striking proof of the steadiness of these monsters is afforded by the statement of the *Cedric's* surgeon to the effect that during her maiden voyage not a single passenger was sea-sick; and that a wineglass, brimming full, placed on the edge of a sideboard, neither moved from its original position nor lost a single drop! This marvellous steadiness is not due to size only, since the

[1] For a description of the mechanism of the steam turbine the reader should consult "The Romance of Modern Invention," pp. 277–293.

Great Eastern, in spite of her enormous tonnage, was a villainous sea-boat, and a very purgatory to passengers with delicate stomachs. Since she was built, designers have mastered the laws which govern the stability of a vessel in heavy weather.

While the fastest times are made between England and America, corresponding improvement has taken place in the times occupied on other routes. The mails are now carried regularly to and from Bombay in 14½ days, the record time being 12½ days by the *Caledonia* in 1893. A passenger may reach Shanghai in 33 days; Hong Kong in 24; Adelaide in 30¼; Cape Town in 15. The cost of travel has also been greatly reduced since Charles Dickens made his memorable voyage to the United States. At present an emigrant may cross from Liverpool to New York for a little over £2, which in five days or more will transport him 3000 miles, while feeding him on much better food than he is probably accustomed to at home. This cheapness is due largely to the competition between rival lines, and cannot therefore be expected to last indefinitely. But even were prices to return to the level of a few years ago, they would still be remarkably reasonable.

The "latest thing" in ocean travel is wireless telegraphy, which robs the liner of any inconvenience arising from separation from the outer world. The Cunard was the first steamship company to systematically employ this latest development of electrical science. In the *Lucania* Mr. Marconi's system was

first permanently set up, and the passengers had the opportunity of witnessing the earliest experiment in the successful maintenance of communication between the ship and the shore. So pleased were the directors with the results then achieved that they at once decided to adopt the invention in their other vessels, and it is now in regular operation in a number of their fastest liners. A small staff publishes a ship's newspaper daily, in which are recorded important events flashed from America or Cornwall, together with the prices ruling on 'Change, so that the business man may know what to expect when he lands. By means of aerial telegraphy a ship is able to keep in touch with another far over the horizon, and call it to help in case of accident or danger. It is no small comfort to the well-housed, well-fed passenger to know that, thanks to the wireless message, he is so near to, though so far from, his fellows.

THE END

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